RICHEY

THE BUILDING MECHANICS'
READY REFERENCE

STONE AND BRICK MASONS' EDITION

BY

H. G. RICHEY

SUPERINTENDENT OF CONSTRUCTION U. S. PUBLIC BUILDINGS

FIRST EDITION
FIRST THOUSAND

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PREFACE.

In preparing this volume of "The Building Mechanics' Ready Reference," it is the idea or intention of the author to give to the Stone and Brick Mason trades a book that can readily be termed a ready reference; something that will be of every-day use and will assist and enlighten the mason in the various branches of his trade.

Tables of various kinds have been used profusely for use as reference and for quick computation, and all problems have been illustrated with cuts so the idea presented by the author can be quickly grasped and understood by the ordinary mechanic.

No long or roundabout methods for laying out or doing work have been given, but everything has been presented as concise and explicit as possible, and at the same time the explanations and cuts are as plain as possible to make them.

The author would be pleased to hear from any reader regarding any error, typographical or otherwise, in this volume, or any ideas or suggestions that may be useful in a future edition. The author's address is care of the publishers.

H. G. RICHEY.

iii

CONTENTS.

PART I.

EXCAVATING. STONE MASONRY. CUT-STONE WORK. STONE-CUTTING. STONE-SETTING. PAINTING STONEWORK. MORTAR AND MATERIALS FOR MAKING.

Excavating.

WHEN starting the masonry of a building the mason should examine the batter-boards, if they have already been put up, to see that they are firm and solid, and check up all the lines and measurements.

If the batter-boards have not already been put up he should put them in place as shown by Fig. 1, keeping them back far enough from the excavation to insure of them being in solid ground.

These boards should always, where practicable, be put up high enough so the lines will be above the belt course, or the first course of cut-stone or brick-work. Lines can then be stretched from corner to corner on these boards

FIG. 1.—Batter-boards and Working Lines.

and working lines can then be set inside the excavation by dropping the plumb-bob from the main line.

In this way if the batter-boards are made solid there will be no changing of the lines and no chance of a mistake by changing the batter-boards from time to time as the walls are built.

Before commencing work the mason should see that the excavation is plenty large enough, so that he can go ahead with his work without having to dig the sides of the excavation down every time he sets a stone.

In damp or wet localities drains are often put in around the outside of the wall as shown by Figs. 2 and 3. Where these drains are to be put, the excavation should be made large enough to permit of the placing of the drain after the wall is built.
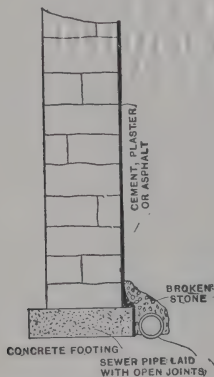
FIG. 2.—Sewer-pipe Drain.   FIG. 3.—Broken-stone Drain.
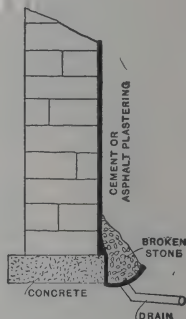
SQUARING LINES, ETC.—The old rule of 6–8–10 is used generally by all mechanics in squaring up their work, and it is

FIG. 4.—Squaring an Angle.

the quickest and most reliable method known except the use of an engineer's instrument.
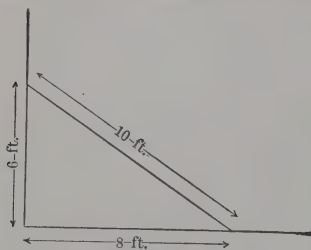
Rule.—Measure 6 feet from the corner on one side and 8 feet from the same corner on the other side, and the diagonal of these two points should be 10 feet, as shown by Fig. 4. If not the lines are not square or at right angles to each other.

An "angle steel tape" is now on the market, the fore part of the tape being made in sections of 6, 8, and 10 feet, connected with movable joints, so that the line can be used for squaring walls, etc., as shown by Fig. 5. This is a very handy tape and will save much time in laying out work.

SHRINKAGE OF EXCAVATED MATERIAL.—All materials when first excavated will increase in bulk, but after lying a while
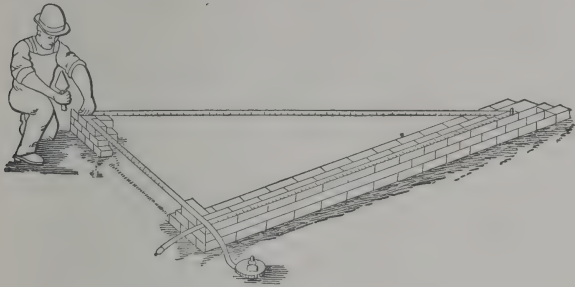
FIG. 5.—Use of Angle Steel Tape.

will, with the exception of rock, shrink until they will occupy less space than when originally in the earth.

The shrinkage of various materials has been estimated as follows:

Gravel.	8	per cent
Gravel and sand.	9	"
Clay and clay earths.	10	"
Loam and light sandy earths.	12	"
Loose vegetable soils.	15	"
Puddled clay.	25	"
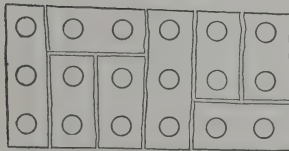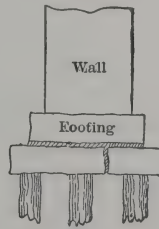
FIG. 6.   Pile-capping.   FIG. 7.

Stone Masonry.

STONE PILE-CAPPING.—In heavy foundations where piling is used the capping is often made of large-dimension stone or granite blocks. These should be of a size to set on not more than

three piles and have joints broken as much as possible, as shown by Figs. 6 and 7. In setting these stones the mason should use every endeavor to have a solid bearing on each and every pile or the stone may break and cause settlement in the building.

STONE FOOTINGS.—Where stone or granite is used for footings, it should be of blocks large enough to extend the full width of the footing, and from 4 to 8 feet in length; where it is not possible to obtain stone large enough to extend through the footing they may be jointed under the centre of the wall and a second course of single stone put on top, as shown by Fig. 8.
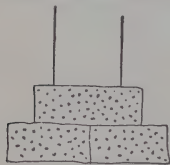
FIG. 8.—Block Footings.

The stone should have uniform beds, and where two or more courses are used the offset should not be more than three-quarters of the height of the under course. The stone should be set in strong cement mortar and on a full bed under the entire stone; stone in footings should not be subject to a pressure of more than 10,000 to 14,000 pounds per square foot.

In buildings which have piers carrying a heavy weight inverted arches are often used to distribute the weight to the footing, as shown by Fig. 9. These arches can be built of either brick or stone and should be built with the same care as an ordinary arch.
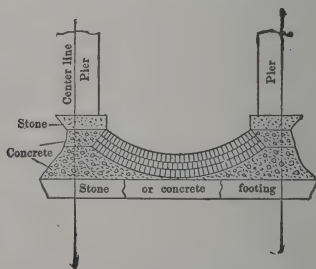
FIG. 9.—Inverted-arch Footings.

In stone masonry there are four points which should be observed and kept in mind by the mason when at work to produce a strong durable wall, viz.:

See that all stones laid in the wall have a flat and parallel "bed" and "build."

Lay all stones on their natural bed.

Make one sixth of the face of the wall headers or through-stones.

Fill all cavities with small stone and mortar.

To build a perfect piece of masonry the above four rules must be followed by the mason. All the stone should be given good beds and face before being set in the wall.

Fig. 10 shows how the headers should be scattered through the wall, as 1, 1, 1, and 2, 2.

Fig. 11 shows the headers in a wall of dimension or block stone in which every alternate stone is a header. This makes the strongest wall possible.
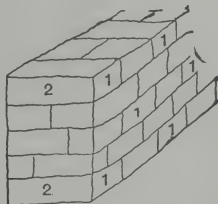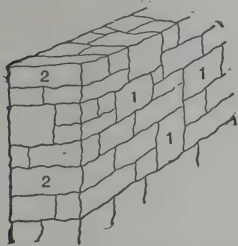
Fig. 10.—Headers in Random Work.   Fig. 11.—Headers in Coursed Work.

The Building Code of the National Board of Fire Underwriters gives the following rules for building stone walls:

HEADERS IN STONE WALLS.—All stone walls 24 inches or less in thickness shall have at least one header extending through the wall in every 3 feet in height from the bottom of the wall, and in every 3 feet in length, and if over 24 inches in thickness shall have one header for every 6 superficial feet on both sides of the wall, laid on top of each other to bond together and running into the wall at least two feet.

All headers shall be at least 12 inches in width and 8 inches in thickness and consist of good flat stones.

No stone shall be laid in such walls in any other position than on its natural bed.

No stone shall be used that does not bond or extend into the wall at least 6 inches.

Stones shall be firmly bedded in cement mortar and all spaces and joints thoroughly filled.

Rubblework.—This is the cheapest and most common of stonework, but is only used for foundation- or cellar-walls, retaining-walls, and such like; stone suitable for this work can

FIG. 12.—Random or Broken Rubble.
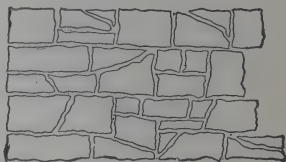
FIG. 13.—Rubblework Laid in Courses.

be obtained in almost any locality. Fig. 12 shows a piece of random rubblework in which there is no attempt made to lay the stone in courses.

Fig. 13 shows a style of random rubble laid in courses from 16 inches to 30 inches in height. This is a good way for a mason to build any rubble wall where much weight is to rest on it, as he will have to level up at the top of each course and start anew, and in this way he will build the wall more solid and get more headers or bond-stones; also at each course he is sure to get level beds.

Fig. 14 shows a rubble wall laid in courses, with a bonding course *A A* between each course of wall; this makes a very

FIG. 14.—Broken Rubble, with Bond Courses *A A* Extending through the Wall.
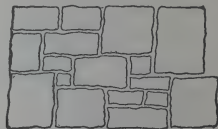
FIG. 15.—Random Range Laid in Level and Broken Courses.

strong wall, as the bond course extends through the wall and ties it together.

Fig. 15 shows random-range work laid in level and broken courses. This is an improvement on the ordinary rubble wall.

In this the stones are dressed nearly square and with level beds, and do not require spalls for filling out the joints, as in ordinary rubble.

Fig. 16 shows the same work, but laid in courses, as in coursed rubble.

Fig. 17 shows block-coursed work, which makes the strongest of stone walls, as all the stones must be dressed to a given thickness and with level beds.

FIG. 16.—Coursed, Random-ranged.   FIG. 17.—Block-coursed.

Fig. 18 shows a wall built of stone dressed in irregular form, with close joints, giving the wall a sort of rustic appearance. This is used only in dwellings or places where something "odd" or unusual is desired. It is expensive and requires great care in working, so that the joints will all have different directions and not more than three to five centre at one place. The stones should all be about the same area on the face,

FIG. 18.—Stone of Irregular Form Dressed to Make Joints.

and dressed so that all joints will be the same size. This is one of the hardest designs of stonework to build, and will require the strict attention of the mason to produce a satisfactory job.

Rubblework is often specified as "one-man" or "two-man" rubble, according to the size of the stones desired to be used and the number of men required to handle them.

COBBLESTONE OR "NIGGERHEAD" FACING.—Retaining-walls, fences, and in some cases walls for dwelling-houses are built faced with cobblestones, or "niggerheads," as they are sometimes called. To keep these stones straight and in line until the mortar hardens is a very difficult piece of work for the mason. A quick and easy method is to build a form of plank

for the face of the wall as shown by Fig. 19, and build the cobble-stones up against this form. This will make a straight and even wall, such as can be obtained in no other way. After the mortar has hardened the form can be taken down and the joints between the cobblestones cleaned out and pointed.
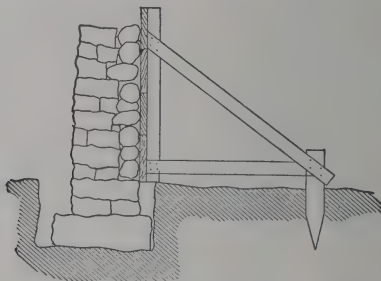
FIG. 19.—" Niggerhead " Facing.

Cut-stone Work.

Ashlar.—The facing of a wall in stone without any regard to the design or style of cutting is called ashlar. The following cuts show the most common methods of laying the stone.

Fig. 20 is regular coursed ashlar, in which the stones are all the same height. In the best class of work the joints are always kept plumb over each other as shown, but in some of the more common work they are placed at random. It is much cheaper, but does not make as nice a looking wall as when the joints are kept plumb.
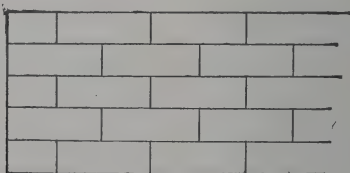
FIG. 20.—Regular Coursed Ashlar.

Fig. 21 shows coursed ashlar of two sizes. This is one of the cheapest methods, as the wide courses are usually but 4 inches in thickness and the narrow courses 8 inches, which gives 4 inches bond in the backing of the wall.

Fig. 22 shows ashlar of irregular courses.

Fig. 23 shows level and broken courses. In this style of ashlar care should be taken to keep the horizontal joints as
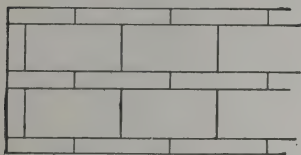
Coursed Ashlar, two sizes

FIG. 21.
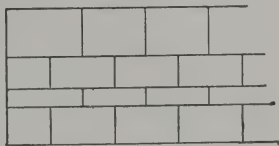
Irregular coursed ashlar

FIG. 22.

short as possible; they should not be more than 3 or 4 feet in length.
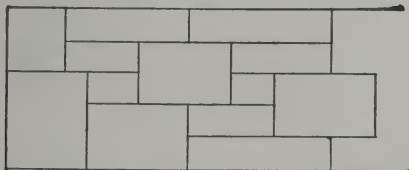
FIG. 23.—Level and Broken Ashlar. Three sizes of stones.

Fig. 24 shows random ashlar, in which the plumb-joints are set at random.
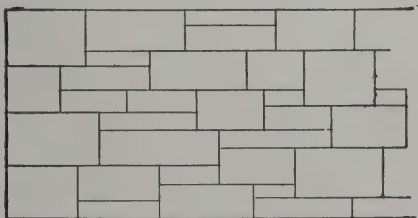
FIG. 24.—Random Ashlar.

Fig. 25 shows the same work improved by keeping the vertical joints plumb.

Fig. 26 shows the ashlar divided into courses 16 or 20 inches in height. To get a nice-appearing wall in all random ashlar-work, the mason should see that the different sizes of the stone

are scattered through the wall as much as possible, and not have a lot of small-size stones or a lot of large ones built in

Fig. 25.—Random Ashlar, Plumb-joints.

at one place and adjoining each other. In all ashlar there should be a bond-stone to every 6 square feet of face of wall,
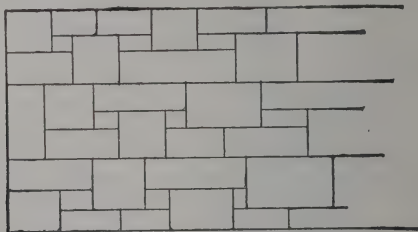
Fig. 26.—Random Ashlar in Courses.

or in coursed work every alternate course should be a bond course.
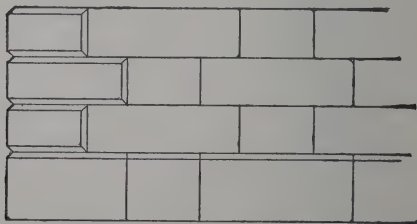
Fig. 27.—Regular Coursed Ashlar, with Chamfered and Rusticated Quoins and Chamfered Base.

Fig. 27 shows regular coursed ashlar with chamfered and rusticated quoins.

Fig. 28 shows rusticated ashlar with moulded base an l sill course. In ashlarwork the stones are usually sawed or dressed at the quarry to the different heights or thicknesses, leaving them to be cut to length at the job. Where the ashlar is in courses, it is customary in large work to have a working-plan showing the size of each stone and the position of all joints. When such a plan is not provided or approved at

FIG. 28.—Rusticated Ashlar.

the commencement of the work the size of the stone, location of the joints, etc., must be left to the judgment of the superintendent of the work.
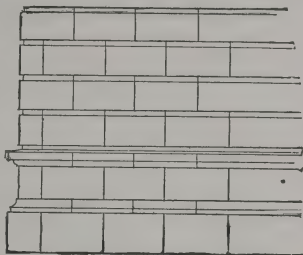
Stone-cutting.

The stone when cut at the job will usually come in slabs sawed on two sides, or perhaps in lengths sawed four sides, giving a smooth surface to the beds and face, as shown by Fig. 29.
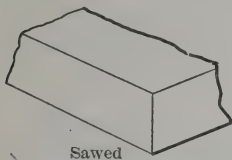
FIG. 29.—Sawed Block.
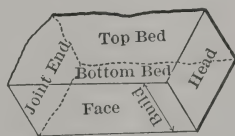
FIG. 30.—Names of Faces of Block.

Fig. 30 shows the names of the different faces of the stone. Fig. 31 shows the various tools used by masons and cutters in dressing stone. B is the mason's or spalling hammer and is used to roughly square or dress a stone for rubblework. C is the mash-hammer used by cutters when using the point in roughing-off and in working the harder rocks such as granite. D is the peen-hammer, which is used to smooth off the surface of a stone after using the point; it is sometimes used on

granite in place of patent hammer, but does not give as desirable a finish. *E* is the pick, which is used for dressing off stone for rough work, such as rubble or block course work
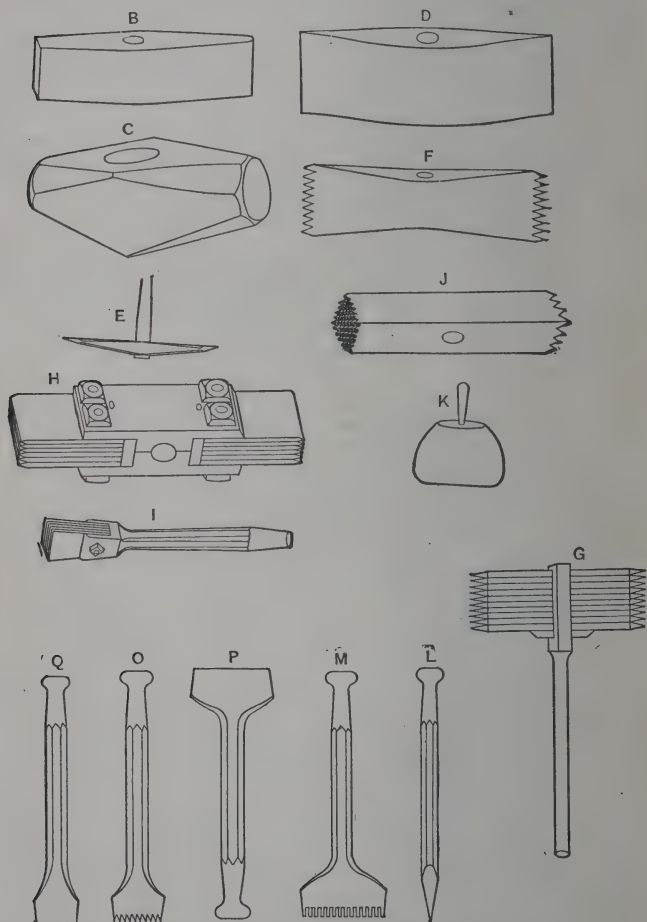
Fig. 31.—Tools Used by Stone Masons and Cutters.

(Fig. 32). *F* shows the tooth-axe, which is used to bring the rough surface of soft stones to the desired plane, ready for the crandall, or tool; it is used also for dressing the beds of

stones. *G* is the crandall, which has a series of points fastened in a handle with a key; this is used on sandstones after the tooth-axe, and gives a smoother surface. Fig. 33 shows the appearance of a stone dressed with the crandall. The tool should be used in different positions, giving the appearance shown at *B*. *H* shows the patent hammer, composed of thin

Picked

FIG. 32.

A Crandalled   B Cross-Crandalled
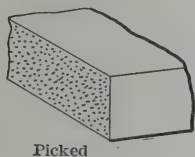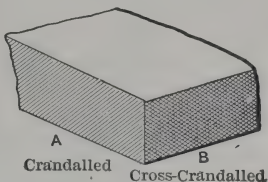
FIG. 33.

blades of sharpened steel bolted together. The fineness of the work is regulated by the number of blades used to the inch, and is specified as 4-cut, 6-cut, or 8-cut, as the case may be. This tool is used only for finishing granite and hard limestones. The patent chisel shown by *I* is used on surfaces where the patent hammer cannot be used. In finishing surfaces with the patent hammer the tool should be held so the blades of the hammer are always in the same direction on the stone. thus giving the stone the appearance as shown at *B*, Fig. 34,
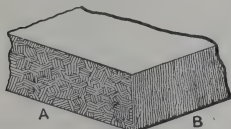
A Finished with the Patent Hammer B

FIG. 34.
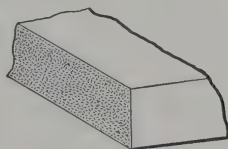
Bush Hammered

FIG. 35.

J is the bush-hammer, which is a square prism of steel whose ends are cut into a number of pyramidal points. The points vary in number and size according to the work to be done. This tool is used after the point or crandall and before the chisel in "drove" or "tooled" work. Fig. 35 shows the appearance of a stone after being bush-hammered. *K* is the mallet, which is used on the point or chisel when working limestone, sandstone, or any other soft stone. *L* is the point, which is

used to roughly dress off a stone, and is also sometimes used to dress the face of a stone as shown by Fig. 36. Fig. 37 shows
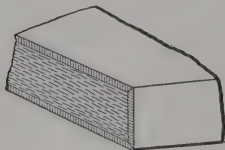
Rough Pointed with Draft

FIG. 36.
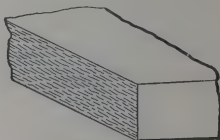
Fine Pointed

FIG. 37.

the same style of finish but on which more pains have been taken, giving it a smoother surface. *M-O* are tooth-chisels, which are used in working soft stones, as they cut faster than the ordinary chisel. *P* and *Q* are chisels, which are made of various widths for different parts of the work. Fig. 40 shows
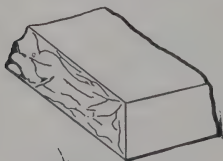
Rock Face

FIG. 38.
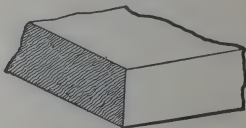
Tooled

FIG. 39.

a stone with a rock face and a draft run around the edge with a chisel. Fig. 39 shows a stone on which a wide chisel has been used over its entire face; this is done before "droving" or "rubbing," and in limestone and sandstone the face is often finished in this manner.
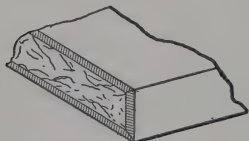
Rock Face with Draft

FIG. 40.

B   A
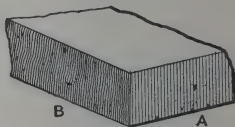
Drove Work

FIG. 41.

Fig. 41 shows what is called "drove" work and is done with a wide chisel after the stone has been tooled and the char-

acter or fineness of the work regulated by the number of "bats," or blows, given the chisel to each inch in the length of the stone, usually 4.

The chisel is generally used across the stone, or lengthwise in the case of mouldings, etc., care being taeken to keep the cuts of the chisel parallel, as shown at A, Fig. 56. B, Fig. 41, shows the appearance of bad workmanship on the part of the cutter, as the tool-marks are all irregular and not straight and parallel.

Fig. 42 shows a piece of drove-work, showing the cuts of the
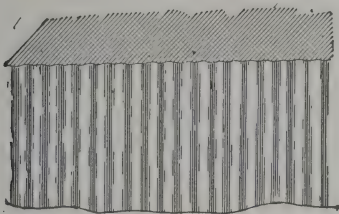
Fig. 42.—Tooled or Drove-work.

tool. Where the cutting is done at the quarry this work is usually done on a machine, and is always regular, but when done by hand requires great care.

Parallel lines should be marked out on the stone, as a guide to hold the chisel; one line to each two "bats" is sufficient. A template made of sheet iron or zinc is shown in Fig. 43,
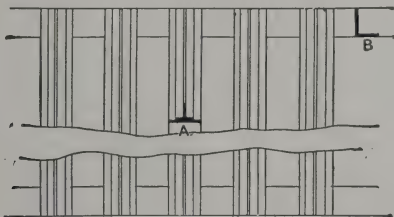
Fig. 43.—Tool for Marking Drove-work.

and is a very convenient tool for marking the stone for this kind of work. It is made, as shown, of a series of bars, A, sol-

dered or riveted to an angle, B, and is laid on the stone like a
square and the lines marked off.

In stone-cutting, all the tools should be used with moderate
force, for with the tooth-axe, crandall, bush-hammer, etc., if
the blow is struck too heavy, it causes the mark of the tool to
penetrate the stone, causing a "sting." In tooled work, if it
is tooled without using the bush-hammer, the marks of the
point, tooth-axe, or crandall will show, and in droved work,
if it is not tooled before being drove, the marks of the bush-
hammer will show.

PROJECTING COURSES.—All projecting courses of stone, such
as cornices, belts, etc., should be cut with a wash on top and

where necessary have a drip cut
to throw off the water. In Fig. 44,
at A, by undercutting as shown,
the arris will form a drip so all water
will drop off at this point; if this is
not done, the water will course
down over the face of the stone to
B before dropping off, and will
always keep the stone covered with
dirt and stain.
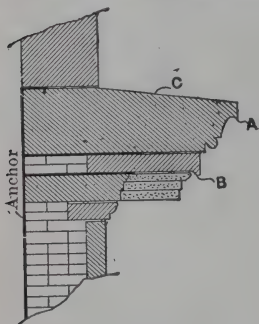
The wash on top of the stone,
as shown at C, Fig. 44, while it
need not be rubbed, as is the case
with washes where exposed to view,
it should be cut comparatively smooth, so that the dirt will not
accumulate to be washed off with the rain, and if a wind is
blowing, blow it against the face of the wall.

FIG. 44.—Stone Cornice.
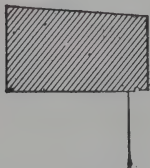
FIG. 45.—Sill with Drip.
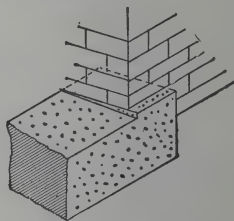
FIG. 46.—Sill with Wash.

Figs. 45 and 46 show how the wash and drip should be cut
on window-sills.

In ordinary work the wash is run the full length of the stone, as the work can then all be done with the saw, but on good work it should stop at the jamb as shown, having the top of the stone level, thus giving a level seat for the brickwork, which is not obtained when the wash runs the full length of the sill.

Figs. 47 and 48 show how the wash should be cut on a sill
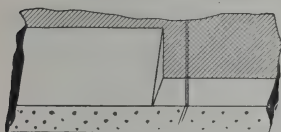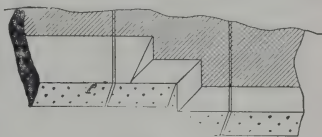
FIG. 47.   FIG. 48.

Wash on Sill and Belt Course.

or belt course where the projections vary. These washes, where exposed to view, should always be rubbed smooth.

LINTELS.—In forming lintels over wide windows or other openings it is advisable, instead of using one long stone, to use

FIG. 49.—Three-stone Arch.

three stones, as shown by Fig. 49, which forms a sort of an arch; or the stone can be notched over and hung on an I beam,

FIG. 50.—Beam-supported Jack-arch.   FIG. 51.—Jack-arch.
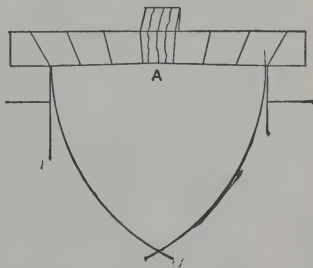
as shown by Fig. 50. Over very wide openings the stone should be cut to form a jack-arch, as shown by Fig. 51.

In cutting stone for an arch of any kind, or any stone on which a great pressure will be exerted, the stone should be cut so that the vein or natural bed of the stone will be at right angles to the pressure, as shown by Fig. 51 at A.

If the stone is cut with the vein parallel with the direction of the pressure, it is liable to split or scale off. In cutting stone for a jack-arch, the under side, or soffet, should be cambered one-half or three-quarters of an inch, as shown by Figs. 51 and 52, as it is more leasing to the eye. If it is cut perfectly straight it has the appearance of having a sag in the centre, especially if the keystone drops below the arch-stone.
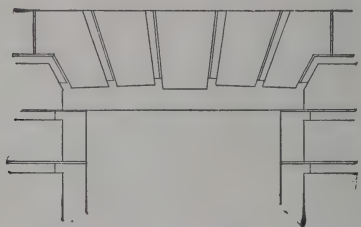
FIG. 52.—Arch showing Camber.   FIG. 53.

In springing a jack-arch over a lintel, as shown by Fig. 52, the arch-stone should be notched over the lintel, as shown by Fig. 53, thus leaving the lintel free and nothing to carry but its own weight.

When setting an arch of this kind care should be taken not to fill the space between the arch-stone and lintel with mortar.

FIG. 54.—Pitch of Steps.   [FIG. 55.—Angle of Coping.
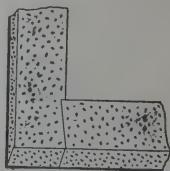
If this should be done and a slight settlement occur in the arch, the lintel would be broken.

Stone-setting.

This branch of building construction is done both by the stone-mason, or stone-setter, and the brick-mason. On work where the stone to be set consists of sills, lintels, etc., they are generally set by the brick-mason. In setting stone it is a custom among some setters to use wooden wedges to adjust the stone and regulate the thickness of the joint. The setter should be careful when using wedges and not raise the stone with the wedge until the wedge carries the entire stone. Wedges should only be used to catch the stone and keep it from settling too low on a soft bed of mortar. Fig. 56, at *A*, shows the result of raising a stone with wedges until there is a space or cavity under the centre of the stone containing no mortar and the stone has a bearing only at the two edges.

By raising a stone on the back and slipping a spall under the same result is obtained, as shown at *B*, Fig. 56. The setter should be very careful to set each stone solid in a full bed of mortar.

When setting stones the joints should be raked out for pointing as the stones are set and the work progresses. This is easier done while the mortar is soft than after it has become hard and has to be cut out with a chisel.

Special care should be taken to keep all projecting mouldings, etc., free from weight.

FIG. 56.

Fig. 57 at *A* shows how a moulded projection may be broken off by bedding the top stone solid without raking out the joint.
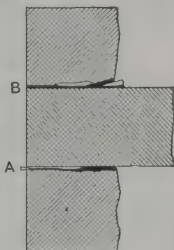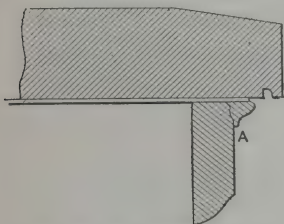
FIG. 57.—Wrong Method of Cutting Moulding.
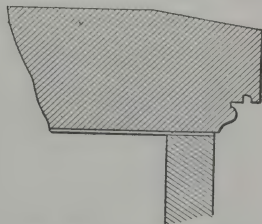
FIG. 58.—Correct Method of Cutting Moulding.

The mortar should be raked out so there will be no pressure on the projecting moulding. If it should be bedded solid

and should there be a little settlement the moulding is liable to be broken off as shown at *A*.

It is better to have such projection cut on the top stone, as shown by Fig. 58

Fig. 59 shows a tool which the author has used with much success in slushing up vertical joints in stonework.
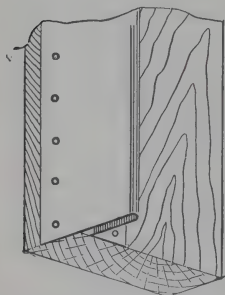
FIG. 59.—Tool for Slushing Joints.　　　FIG. 60.—Use of Slushing Tool.
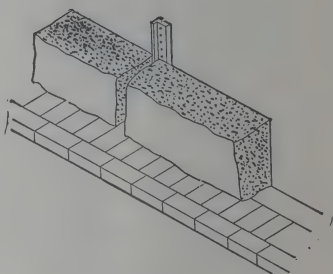
It is made, as shown, of a strip of wood about $1'' \times 3''$ and as long as desired, with a piece of sheet iron or zinc bent and nailed on as shown, the projection of the metal from the strip being the depth at which it is desired to leave the joint open for pointing. To use the tool this projection is inserted in the joint, as shown by Fig. 60; the mortar is then slushed in against the strip until the joint is full. This saves raking out the joint, keeps the face of the stone clean, and insures the joint being open to the desired depth. As will be seen by the way it is made, it can be used in the angles as well as on the face of the wall.

In setting all stones which are to carry a heavy weight, the mortar should be kept back far enough from the face of the stone so that there will be no danger of the corner being chipped off by the pressure on the stone.

The joint in cut-stone work should not be more than one-fourth inch, and for rock-face work not over three-eighths inch.

In setting projecting courses, such as cornices, etc., the stone when being set should be bedded but little beyond the face of the wall, as shown by Fig. 44, page 16, the balance of the joint being filled when the pointing is done; in this way every stone is responsible for its own weight and leverage, and the lower courses do not have to carry the weight of

the top stone. The stone in a cornice should always extend back in or through the wall, so that there will be weight enough in that part of the stone in the wall to overbalance the over-

FIG. 61.—Lead Cap-joint.

hang, or projection; then the top stone should be anchored as shown.

The top of the joints in the cap course of a cornice or other wide projection should be covered with lead, as shown by Fig. 61, the lead extending down into the joint about 2 inches
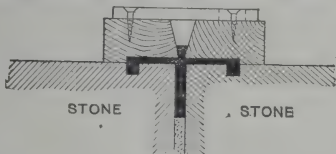
FIG. 62.—Mould for Running Lead Cap.

and over into channels cut in the stone as shown. Fig. 62 shows the section of a mould which the author has used for running the lead hot into the joints, and made a very satisfactory job, much better than cementing the lead. By running the lead in hot, all the crevices and channels are filled solid and the

FIG. 63.—Raised Cap-joint.

lead takes hold of the rough surface of the stone and cannot get loose or come out.

Another good method of making the joints of capstones of cornices, etc., water-tight is to cut the stone with a raised lug at the joint, as shown by Fig. 63, and put on a lead cap as shown. This makes a joint that is perfectly tight to the weather.

In setting stone a good method is to lay out a pole giving the different courses and joints of the stonework from some projecting course, as a belt course, as shown by Fig. 64, then the corner-stone can be set to height from this pole and the walls kept at the correct height and level.
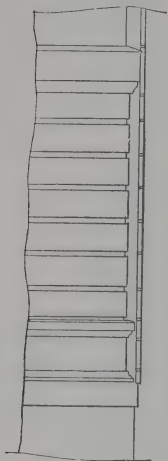
FIG. 64.—Course Pole.
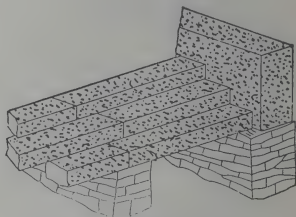
FIG. 65.—Step Foundations.

STEPS.—Steps should be set as shown by Fig. 65, being carried on the wall at each end; in this way there will be no danger of breaking in case there is any settlement, as would happen if the steps were bedded their entire length.

FLAGGING.—Stones for flagging or sidewalks should be set on a bed of broken stone or cinders extending below the frost-line, or a better method is to set them on dwarf walls, as shown by Fig. 66. After being set, the joints should be thoroughly filled with strong cement mortar and the stone gone over and any irregularities at the joints dressed off.

FIG. 66.—Supporting Flagging.
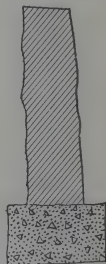
FIG. 67.—Foundation of Curb.

In setting a curb, it should be kept on a bed of broken stone, and the curb itself be wide enough to extend below the frost-line, as shown by Fig. 67.

Pointing Stonework.

The pointing of stonework is usually done as soon as the exterior part of the building is up, unless this part of the work is reached in cold weather, as no pointing should be allowed during weather when the mortar will freeze, either during the day or night. In extremely ot weather, if pointing is done it should be protected by hangi 1z canvas or muslin over it to keep off the hot rays of the sun, as the heat will dry it too fast and the cement will lose its strength. All joints before pointing should be raked out at least three-quarters of an inch deep.

This rakin out should be done when the stones are set, as previously described; it can be done so much better and cheaper while the mortar is soft than after it has hardened.

When the pointing is to be done the joints should be brushed out clean and thoroughly vet with water; tle mortar should then be packed solid in the joint.

MORTAR FOR POINTING.—The mortar for pointing should be mixed with cement and fine sand or marble-dust, so that the mortar will d e s off smooth unde the jointing-tool.

Fig. 68 shows some of the different styles of pointing. With the styles AA the corner of the stone acts as a guide for the tool, but with raised designs the tool should be held against a straight-edge; an ordinary short straight-edge with a couple of blocks tacked on the side to hold it up off the finished joints answers the purpose, and the joints will then be made straight.

Before pointing, the walls should be brushed clean and washed down with a wash to remove all stains or spots of mortar, etc.

The most common wash used is a solution of dilute muriatic acid, which neutralizes the dirt and surplus mortar and takes it off very quickly. There are some stones that are injured by acids and this solution should not be used on any such stones. Pearline, lye, etc., also will make a good wash for cleaning down walls. In England a method of cleaning down stonework with a steam-jet has been used with good results.

The mortar for pointing should be used very stiff and should be rammed or packed solid into the joint. A mason by doing a good job of pointing may save his employer much future worry and expense.

There is no part of building construction that will show up so soon as a bad job of pointing.

MEASUREMENT OF STONEWORK.—Rubble stonework is usually done by the perch, which is 24¾ cubic feet, or, as is more convenient, 25 feet. However, in some localities custom has made it a rule to call any number of feet from 16 to 25 a perch,
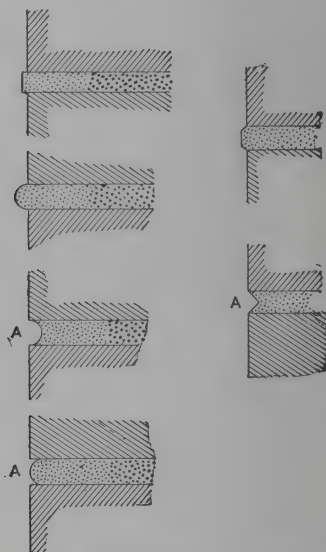
FIG. 68.—Styles of Pointing.

according to the custom of the locality; so it is best when work is done by the perch to have an understanding at the commencement how many feet are to be considered a perch. It is also well to have an understanding as to what openings are to be counted as solid or what are to be left out in measuring the wall.

In measuring stonework always measure from the outside, thus measuring all the angles twice.

All walls under 18 inches are counted same as 18 inches.

Ashlar and dimension or block stone are usually measured by the cubic foot; mouldings, belt courses, etc., by the lineal foot; flagging and such like by the square foot.

One and one-quarter barrels of lime and 1 yard of sand will lay 100 feet of stone rubblework.

One man with one tender will lay 150 feet per day.

One and one-quarter barrels cement, ¾ yard sand, will lay 100 feet stone rubblework.

One barrel cement to three of sand will lay about 2 perches of rubble stonework.

Mortar and Material for Making.

The following extract from an article on mortar was taken from the *Irish Builder:*

"Like all other compounds, mortar depends for its quality upon that of its constituents, and also upon the proportions in which they are used, and the method by which they are mixed. To all intents and purposes it is an exceedingly fine concrete, composed of an aggregate and a matrix mixed with water, its purpose being to fill up the interstices in the joints between the bricks or stones of which a wall is composed, so as to provide an even bedding surface and render the wall watertight, adherent properties being rather valuable for securing this than needed to prevent the bricks from being pulled apart.

"Thus it comes about that the more close the jointing of a wall is, the finer should be the grain of the mortar and of its aggregate. A course rubble wall having wide, irregular mortar joints would be best with a mortar made of a fine gravel or crushed stone, or, at least, with one which contained a considerable amount of pea-sized lumps as well as finer sand amongst the aggregate, to assist in filling up the larger hollows without undue liability to settlement. On the other hand, for well-dressed ashlar masonry the finest sharp-grained sand obtainable should be used, there being only very small cavities to fill up, and the very thinnest possible joint being required.

"Beyond this it is necessary in all cases that the aggregate should, under a magnifying-glass, display either sharp edges or a roughened surface or both, in order that the matrix may adhere to it; for, while there is little necessity to stick the bricks of a wall together if they be properly laid, it is quite necessary that the mortar should form in itself a homogeneous substance, else it will crumble into dust or wash out of the joints."

LIME MORTAR.—Lime mortar is made by slaking the lime and adding sand in the desired proportion. The slaking is usually done by putting the lime in a water-tight box and covering with water. The lime is then stirred with the hoe so as to let the water get to all sides of the lumps of lime and thus cause it to slake more readily. Enough water is added to make the mixture about the consistency of thick cream. It is then run off through a sieve into a larger box, where the sand is added and the mortar allowed to cool a little and thicken. The amount of sand used is regulated by the quality of the lime used, as some limes will take more sand than others.

The "mortar-man" when slaking lime can usually tell when he has enough sand added as he "runs it off," but if it is a little "rich," as it usually is, he will add more sand when he tempers it up for use. The mortar should have just enough sand in it to make it work nicely and not stick to the trowel.

The "mortar-man," by a little experience with and watching the mortar, will be able to tell at a glance if the mortar is "rich" or "poor." Mortar should be run off at least three days before using, so that the lime will have time to cool off and there will be no small particles of lime left unslaked and which may slake after being built in the wall.

Lime mortar should not be used in freezing weather, although if it is frozen hard and dry without any thawing it hardly ever affects it much, but if it is alternately frozen and thawed the mortar will lose its strength and be destroyed; so, to be on the safe side, it is well to follow the rule of using no lime mortar in freezing weather.

Ground lime is now used in nearly all parts of the country, as this lime can be mixed and used immediately.

In making mortar for laying "press" brick or brick with a close joint, a fine white sand or marble-dust is generally used.

The New York Building Code requires that lime mortar be made of 1 part of lime and not more than 4 parts of sand.

SUGAR IN MORTAR.—Sugar has been used for centuries in India in the making of lime mortar and is said to add greatly to its strength. Experiments were made some years ago to ascertain the effect of sugar on Portland cement, and an addition of from $\frac{1}{8}$ to 2 per cent of pure sugar added to Dyckerhoff German Portland cement was found to considerably increase its strength after three months. The sugar was said to "retard

its setting," and thus permit the chemical changes in the cement to take place more perfectly, but more than 2 per cent of it rendered the cement useless. As sugar is soluble in water it should never be used in mortar which is to be used under water.

PORTLAND-CEMENT–LIME MORTAR.[1]—"There are many kinds of work which require a quick-hardening mortar, but for which the great strength of a mixture of 1 of cement with 1 to 4 of sand is unnecessary. The cost of such mortar is also for many purposes too high. A mixture of cement with 5 or more parts of sand would give abundant strength, but such mortar works too 'short' and adheres too imperfectly to the stone or brick; it cannot therefore be safely used. In such cases the addition of slaked lime or hydraulic lime will correct the faults of poor mixtures of cement and sand, and will produce a cheap mortar suitable for a great variety of uses. Used in this manner, Portland cement may be used with economy for the most ordinary purposes. The advantages of Portland-cement–lime mortar are its cheapness in comparison with other hydraulic materials, its rapid hardening, marked hydraulic properties great strength on exposure to air, and remarkable resistance to weather.

" The following mixtures for cement-lime mortar have been found by experience to be most suitable:

" Cement, 1 part;	sand, 5 parts;	lime paste, ½ part
" 1 "	" 6 to 7 parts;	" " 1 "
" 1 "	" 8 parts;	" " 1½ parts
" 1 "	" 10 "	" " 2 "

"The above proportions are to be taken by measure. Hydraulic lime may be used in the place of ordinary slaked lime.

"Cement-lime mortar is prepared by making a dry mixture of the required quantities of cement and sand; milk of lime is then made with the necessary quantities of lime paste and water and this milk of lime thoroughly mixed and worked in with the mixture of sand and cement."

In laying face brick in cement mortar it is advisable to add a little lime "putty" to the mortar, as it makes the mortar work smooth and the mason can do a neater job. Mixtures of cement with three parts or more of sand are found to work

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[1] Extracts from " Das Kleine Cement-Buch."

too "short" for rapid and easy work in laying brick or stone. The addition of lime paste removes this defect and makes the mortar smooth and plastic. The adhesion of the mortar to brick or stone, and also its impermeability to water, are greatly increased by the addition of slaked lime. As to strength, it will be found that a mixure of Portland cement 1, lime paste 1, sand 6, is as good in every respect as a mixture of Portland cement 1, sand 3; or, in other words, that one-half the cement may be replaced by lime paste without loss of strength.

Compared with mortar made with Louisville, the Portland-cement–lime mortar will be found immensely stronger and little or no more expensive.

CEMENT MORTAR.— In making cement mortar the strength of it depends on the quality of the cement and sand, the proportions used, and the manner of mixing. The sand should be sharp and irregular, as described on page 30, the finest depending on the nature of the work in which the mortar is to be used.

For mortar for laying brick or for grouting, it should be comparatively fine, while for concrete or coarse mortar it should range from fine to coarse. A small amount of pure clay in the sand used for cement mortar will not affect its strength.

Proportions.—The proportions of cement and sand for cement mortar varies according to the cement used and the strength of the mortar desired.

The most common mixture is 1 to 3 for Portland cement and 1 to 2 for natural cements. There must be enough cement to more than fill all the voids in the sand and make a compact mass.

For masonry and brickwork use 1 part cement to 2, 3, or 4 parts of sand, according to the strength required and the purposes for which the mortar is to be used; for some special purposes 5, or even 6, parts of sand may be used.

Cement mortar for face brickwork is usually composed of 1 part cement and 2 parts sand; for backing and in ordinary masonry foundations it is not necessary to use a richer mortar than 1 part cement to 3 of sand. When large quantities of sand are used the mortar is "short" and brittle and will not work well.

In some cases lime paste is added to the cement mortar to

give it the required plasticity. The proportions are about one-half part lime paste added to the mortar.

Stone-dust and fine screenings have been used as a substitute for sand and gave as strong a mortar as if sand had been used. The table on page   shows the average str ngth of cement mortars of different proportions and age.

WATER-TIGHT MORTAR.—For the lining of cisterns and reservoirs, and also in some cases for the protection of underground conduits and piping, a mortar which is impermeable to water is required.   According to Dykerhoff the following mixtures will be found water-tight as soon as set:

> Portland cement, 1; sand, 1;
>   "   "   1; "   2; lime paste, $\frac{1}{2}$
>   "   "   1; "   3; "   "   1
>   "   "   1; "   5; "   " $1\frac{1}{2}$

From the above mixtures the one may be chosen which offers the required strength and hardness.

A solution of 1 pound of concentrated lye, 5 pounds of alum, and 2 gallons of water mixed with cement in the proportion of 1 pint of the solution to 5 pounds of cement and applied with a brush and well rubbed in will make cement walls waterproof.

To COLOR CEMENT MORTAR.—*Black.*—Use 45 pounds of manganese dioxide to a barrel of cement.

Brown.—Use 25 pounds of best roasted iron dioxide to a barrel of cement, or 15 or 20 pounds of brown ochre.

Blue.—Use 19 pounds of ultramarine to a barrel of cement.

Buff.—Use 15 pounds of ochre to a barrel of cement, but this will greatly reduce the strength of the mortar.

Green.—Use 23 pounds of greenish-blue ultramarine to a barrel of cement.

Gray.—Use 2 pounds of Germantown lampblack (bone-black) to a barrel of cement.

Red.—Use 22 pounds of raw iron oxide to a barrel of cement.

Red-bright.—Use 22 pounds of Pompeiian or English red to a barrel of cement.

Purple.—Use 20 pounds of prince's metallic paint powder to a barrel of cement.

Violet.—Use 22 pounds of violet oxide of iron to a barrel of cement.

Yellow.—Use 22 pounds of ochre to a barrel of cement.

Ultramarine is one of the best coloring materials, as it does not affect the strength of the mortar. Germantown lampblack is also good on account of the small quantity necessary to give a good color.

Do not use common lampblack or Venetian red, as they are liable to run and fade.

In coloring mortar the coloring should be mixed in the sand and cement dry, and the wet mixture should be made several shades darker than required, as the wet mortar looks darker and brighter to the eye, owing to the gloss of the water, than it really is

Mortar is one of the principal materials used in construction, and upon which the strength and stability of the structure depends to a great extent; hence the different materials and proportions used in making the mortar should be the best of their several kinds.

SAND.—Sand, which enters largely into the composition of all mortars, should be sharp and angular and comparatively free from any dirt or loam. Recent experiments have shown that a slight percentage of clay in the sand used for cement mortar does not affect its strength, but there should not be more than 5 per cent of clay in the sand. For rough stonework or common brickwork the sand should be coarse, but for "press" brick and setting ashlar it should be fine, so as to get a close joint.

The sand for mortar for either stonework or brickwork should be clean, coarse, and sharp. A good quartz sand is the best.

A very fine sand does not make as good mortar as the coarse, and very fine sand should not be used unless for brickwork where a close joint is desired; but when the sand is used in large proportions to the lime or cement, a sand ranging from fine to coarse will make the best mortar. A loamy or dirty sand should not be used, as it will weaken the mortar.

Marble-dust is often used in place of sand where a close joint is desired in the work.

By taking a small amount of sand and spreading it over the hand or examining it with a magnifying-glass a person can readily ascertain its quality.

QUICKSAND.—Sand which has been worn round and very fine

by the action of water is known as quicksand and should never be used in making mortar or concrete. This sand is easily distinguished, as the particles are round and very small, some of it being almost a powder. In the pile it is continually running down, thus making a very flat pile.

Good sharp sand can be cut down in the pile with a perpendicular face, but this cannot be done with quicksand, as it slides like so many round balls.

When used in mortar quicksand will settle to the bottom and the mortar has to be continually mixed or tempered. Sand of this kind will make a very weak mortar or concrete.

Lime.—Lime is obtained by burning limestone. When carbonate of lime is calcined the carbonic acid is thrown off and lime is obtained. It is then known as caustic lime or quicklime; if it then be mixed with water it will throw out great heat, swell to several times its original bulk, and finally falls to a powder. In this state it is known as slaked or a hydrate of lime.

The quality of lime depends on the composition of the limestone from which it is made. Those stones which are nearly pure carbonate of lime make the best lime, while those which contain large amounts of impurities, such as silica, clay, magnesia, and alkalies, make the poorest lime according to the amount of impurities contained.

Good lime should be free from cinders or unburned stone and not contain a large per cent of impurities; over 10 per cent of impurities makes poor lime and it should be rejected.

Lime should be in large hard pieces and contain little dust. When wet with water it should slake readily into a smooth, fine paste or putty. The lime should slake by simply immersing it in the water, although stirring it will hasten it somewhat.

HYDRAULIC LIME.—Hydraulic lime is made from calcareous rock containing 12 to 30 per cent of silica, alumina, iron, and magnesia; when calcined at a low temperature it will slake and will set and harden in water in from one to ten days to five or six months, depending on the amount of silica and alumina contained. Hydraulic lime is not used much in this country, as natural cement takes its place. The following is an average of French hydraulic lime:

Silica.......................... 22.0 per cent
Alumina....................... 2.0 " "
Oxide of iron.................. 1.0 " "
Lime.......................... 63.0 " "
Magnesia...................... 1.5 " "
Sulphuric acid................ 0.5 " "
Water......................... 10.0 " "

100.0 per cent

Cements.—Natural cements are generally called Rosendale cement, from the name of the town in New York where it was first made in this country. It is made from a natural rock containing about 60 per cent of lime and magnesia to about 40 per cent of silica and alumina, with a little iron or potash. This cement sets and attains its limit of strength much quicker than Portland, and is used where extreme strength is not necessary. Portland cement, because the price is becoming cheaper than in former days, is now fast taking the place of Rosendale cement.

Rosendale cement is usually a dark brown; a light color indicates an inferior cement.

WEIGHT AND CHEMICAL ANALYSIS.—*Weight.*—The average weight of Louisville or Rosendale cement is as follows:

1 cubic foot, loose.................. 55½ pounds
1 cubic foot, packed. 74   "

Therefore a barrel of 265 pounds contains 4.77 cubic feet of loose cement and 3.58 cubic feet of packed cement.

Louisville cement is shipped in three kinds of packages: barrels, weighing 285 pounds gross; paper bags, 82 pounds each; and jute sacks, weighing 133 pounds each.

PORTLAND CEMENT.—Portland cement is what is known as a tricalcic cement and is composed of lime, silica, alumina, iron oxide, and magnesia artificially blended together into a scientifically correct mixture and burned at a white heat. The process varies greatly with the character of the raw materials used.

By the heat of the kiln the silica, lime, alumina, and oxide of iron become silicate of lime and alumina, and aluminate of

lime and ferrite of lime.   If the composition of these compounds is brought about in the right proportions in the molecule and in the mass, their nature is to crystallize when wet with water and then harden till they become as rocks.

When any lime leaves the kiln uncombined and is not changed to hydrate of lime, or carbonate of lime by exposure to the air, the uncombined lime will act as a deleterious ingredient, and is the cause of the swelling of cement in barrels and the checking and blowing found in finished cement-work; if the cement contains any of this uncombined lime it will generally show in the tests made for soundness or expansion.

Nearly all the Portland cement made in this country is produced artificially. The name "Portland" is given the cement on account of its color when hardened, which resembles the color of a stone found on the isle of Portland, off the coast of England.

The quality of Portland cement depends on the raw materials used, their proportion, and fineness to which it is ground.   Portland cement sets much slower than the natural cements and requires a much longer time to reach its limit of strength, but attains a much greater strength than the natural cement.

The color of Portland cement is a dark-bluish or drab color. It should weigh at least 375 pounds per barrel and four sacks should equal a barrel.   A cement which is lighter in weight than this is liable to be poor.

PUZZOLAN CEMENT.—This was originally an imported cement, made from a natural burned material of volcanic origin, but several slag cements now being made are really Puzzolan cement and should be classed under that head.

The so-called slag cement is the product obtained by pulverizing, without calcination, a mixture of granulated basic blast-furnace slag and slaked lime. This product, though in reality a member of the class of Puzzolanic cements, is usually marketed as "Portland cement," in spite of the fact that it differs from a true Portland cement in method of manufacture, ultimate and rational composition, and properties.

Mixing Mortar.—In mixing lime mortar the strength of the mortar or amount of sand to be used is usually left to the judgment of the "mortar-man," for by experience he can tell by the working of the mortar when he has given what sand the lime will carry. No definite rule can be given for

measuring sand in lime mortar, for some limes will take more sand than others.

In mixing cement mortar the wheelbarrow is often used as the unit of measure, but at times it is difficult to get the workmen to measure correctly by this method, and the author presents the following method, which he uses:

Obtain the depth of the mixing-box and make a straight-edge, as shown by *A*, Fig. 69, so as to strike off the sand and cement at the proper levels to measure it correctly.
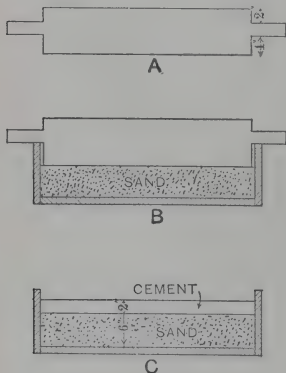
Fig. 69.—Measuring Mortar Materials.

In the example shown by Fig. 69, the box is 10 inches deep and the mortar to be mixed 1 to 3. We will notch one side of the straight-edge 4 inches, which will strike off the sand in the box 6 inches deep. On the opposite side of the straight-edge we will make the notch 2 inches deep, which will strike off the cement 2 inches deep on top of the sand, thus giving a layer of sand 6 inches deep with a layer of cement on top 2 inches deep.

This method can be used for a full box of mortar or any part of a box. The author has derived much satisfaction by using this method, as it insures the sand and cement being measured correctly, and it also spreads the cement over the sand uniformly, so that the mixing is much easier and more uniformly
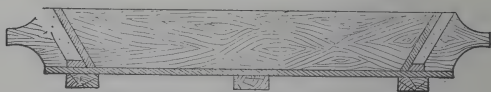
Fig. 70.—Mortar-box.

than when the cement is thrown on top of the sand without spreading it in a uniform layer.

MORTAR-BOX.—Fig. 70 shows how a mortar-box should be built. The handles at each corner, as shown, enables four men to carry it very easily. The ends should always be set

on a slant, as shown, so the blade of the hoe can be got down into the angles and the box scraped clean. At the close of the day's work the box should be scraped and washed clean.

RULES REGARDING USE OF MORTAR.—Lump lime-mortar should be made up three or four days before required for use and then tempered as desired.

Ground lime can be used the same day it is made into mortar, but it is better to let it stand a day before using.

Do not use mortar that is too soft or sloppy, as neat joints cannot be made.

Do not use mortar of any kind in freezing weather.

Have cement-mortar mixed so that none of it will stand over two hours before being used.

When mixing cement-mortar mix the sand and cement dry to a uniform color before adding the water.

Grouting.—Grout is a thin mortar usually made of sand and cement, and is generally used in brickwork, by building up the two outside courses of the wall, then laying the inside bricks and pouring the thin mortar over them, working it well into all the joints. The grouting should be done every course, so that all the joints will be filled solid.

Grouting is done when extreme strength and solidity are desired.

PART II.

BRICKS AND BRICKLAYING. RULES FOR
GOOD BRICKWORK. TERRA-COTTA WORK.
ESTIMATING BRICKWORK. STREET-PAV-
ING.

Bricks and Bricklaying.

THE quality of a brick depends on the material used, the care in its manufacture, and the manner in which it is burned. With the machinery that is in use at the present time it is possible to use different materials and make better brick than in former days when clay was the only material used and the bricks were moulded by hand.

For common bricks a shale rock makes perhaps the best brick, and when burned with gas, as quite a number are now burned, they make a very hard brick and of uniform size and color.

The chemical compounds contained in the material used determines the color and quality of the brick to a great extent; if there is much silicate of lime in the material used, it renders the clay too fusible and causes the brick to soften and warp or twist in burning. A small amount of sand is beneficial, as it tends to prevent shrinkage from the heat in burning.

Iron gives hardness and strength to the brick, and also causes the red color in burning, the color depending a great deal on the amount of iron contained.

In face or front brick iron or mineral pigments are some-times added to the clay so as to color the brick as desired.

Where the bricks are exposed to excessive heat in burning, the iron fuses and produces a dark-blue or purple color, as shown by the "arch" or clinker brick next to the fire in the kiln.

When the clay contains much magnesia with the iron it produces a yellow color.

NAMES OF BRICK.—All brick not hard enough to stand in the outside of buildings are known as "salmon" or "soft" brick.

All brick hard enough for use in the outside of buildings, but not selected or graded, are known as "hard kiln run."

All brick set in the arches or benches of the kiln and which are discolored, broken, or twisted in the burning are known as "arch brick."

All common brick selected for the outside of buildings are known as

Front brick: $\begin{cases} \text{No. 1 light-burned,} \\ \text{No. 2 medium-burned,} \\ \text{No. 3 hardest-burned.} \end{cases}$

All brick used for sidewalks are known as "sidewalk brick."

All the brick in the kiln not strictly soft taken together are known as "merchantable brick."

All brick that are set in the kiln when burned are known as "kiln-run brick."

Bricks moulded either by hand or machinery in rough, coarse sand and repressed without rubbing, so as to give the brick a rough sand finish, are known as "stock" or "sand-struck" brick.

All brick other than square are known as "ornamental brick."

All brick made either by the repress or dry-press process, and selected for fronts of buildings, are known as "press brick," which are: No. 1, light shade; No. 2, medium; No. 3, dark.

SIZES OF BRICKS.—The sizes of bricks vary much in different parts of the country, and when brick and stone are worked together the architect should know what brick he is going to use, so as to know its size and in preparing the drawings make the sizes of stone to suit the brick. The author has known of cases where the contractor had to ship bricks several hundred miles just because the bricks which were made near the work were not of a suitable size to work with the stone as laid out and figured for the building. This is in regard to the face brick, although the common brick should work with the stone so as to get the correct bonding. To lay English cross-bond

correctly the length of the brick should equal twice the width of the brick plus the thickness of one mortar joint.

WEIGHT OF BRICKS.—The weight of bricks varies, according to size and their density, from $4\frac{1}{2}$ to $5\frac{1}{2}$ pounds; in the wall a cubic foot of brickwork will weigh about 115 pounds.

QUALITY OF BRICK.—Good building brick should be uniform in size and color and hard and well burned. When two bricks are struck together they should give forth a clear-ringing sound. When broken with a hammer they should break across the brick, dividing it into two "bats," and produce a clean fracture showing a compact, hard structure, having a bright surface free from cavities and air-holes. A soft brick when broken will usually fly into several pieces.

The brick should have square edges and parallel surfaces, and not be twisted or warped by burning.

A brick should not absorb more than one-tenth of its weight of water.

As a rule, the darkest bricks are the strongest and best burned while the light-colored ones are usually soft and will not stand much crushing strain or the weather. A good test for a brick is to heat it red-hot and then pour cold water on it; if it does not crack or break it is of excellent quality.

A good brick supported at each end on supports 6 inches apart should withstand a pressure at the centre of 2000 pounds without breaking.

In a test made by Norcross Bros., of Boston, the crushing strength of brick ranged as follows: 2720 pounds for light hard, the poorest; up to 8000 pounds per square inch for the best quality to produce the first crack, while the ultimate strength ran from 3149 up to 10,532 pounds per square inch.

BRICKLAYING.—The strength and stability of a brick wall depends, in addition to the quality of the materials used, upon the manner in which it is built. Therefore no matter how good the materials used may be, it depends on the mason to put them in place properly and obtain the greatest strength.

There are several points that a brick-mason should continually bear in mind if he is desirous of building a strong and substantial wall. They are as follows:

1. Lay each brick in a full bed of mortar.

2. Slush each joint full of mortar.

3. Keep all leads and corners plumb.

4. Do not let the work get "hard" against the line and out of plumb.

5. Keep the brick down to a tight joint.

6. Put in plenty of headers.

7. "Strike" or joint all exposed joints neatly.

8. Use the best of mortar.

9. Have all brick wet before being laid, especially if laid in cement mortar.

To get the full strength of the brick each one should be set in mortar over its entire bed and be "shoved" or beat down
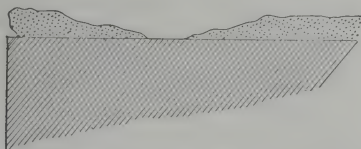
FIG. 71.—Mortar Spread for Laying Brick.

until it is solid. Unless the mason uses some care and judgment in spreading the mortar with the point of the trowel there will be a cavity under the centre of the brick when set.
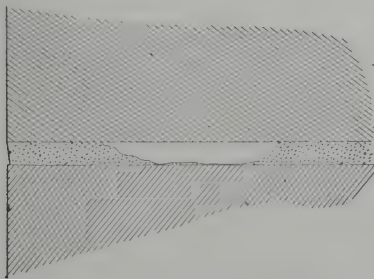
FIG. 72.—Poor Joint in Brickwork.

Some masons with a blunt-pointed trowel will spread the mortar as shown by Fig. 71, and when the brick is set it has an open space under its entire length, as shown by Fig. 72.

This is often a defect in laying front brick with "butter" joints; the mortar is placed on the brick to be laid in the manner shown by Fig. 73, and when laid the result is shown by Fig. 74, leaving the centre of the brick without any bed.

FIG. 73.—Spreading Mortar for "Butter" Joint.

The author has seen work of this kind where the weight of the wall had caused pieces of brick to spall off, as shown in Fig. 74, just because the brick did not have a full bed of mortar.

It is customary in building brick walls to carry up the outside course of brick "header high" and then fill in the backing. In doing this the mortar should be soft enough to be readily slushed into and fill the joints, and if the brick are "shoved" into position it will force the mortar into the joints and make a solid wall.

The mason should use especial care at all corners and angles to keep the brick plumb and straight, and should sight along his line once in a while to see that he is not working "hard" on the line and thus cause the wall to "overhang" or be out of plumb.
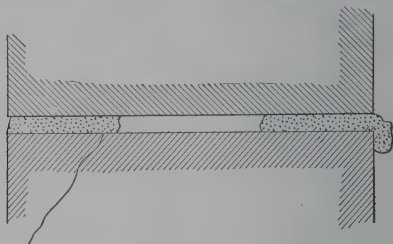
FIG. 74.—Spalled Brick Caused by Poor Joint.

JOINTS.—The joints of brickwork should be kept as small as possible. The bed joints for common brickwork should be about $\frac{3}{8}$ inch, but depend a great deal on the mortar used. In "stock" or "sand-struck" brick for outside work the joint should be $\frac{1}{4}$ inch, and for "press" brick $\frac{1}{8}$ or $\frac{3}{16}$ inch.

HEADERS.—One of the vital points for strength in a brick wall is its headers. Take out all the headers and a wall of any height would collapse. The strongest wall built of brick would be one with headers every third course, and in all brickwork not over every fifth course should be a header course.

The headers should be lapped and carried back through the wall, as shown by Figs. 75 and 76.
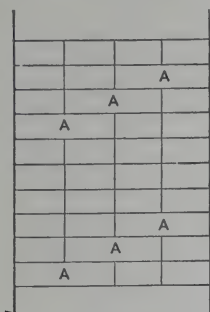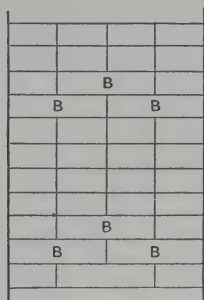
Fig. 75.   Fig. 76.

Headers in Brickwork.

In facework where it is not desired to show the headers they are usually put in as shown by Fig. 77. This is called
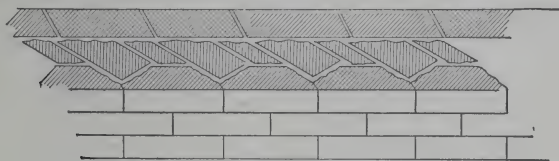
Fig. 77.—Clipped Bond.

clipped or diagonal secrete bond. Fig. 78 shows another style of secrete bond; the stretcher course is clipped to half
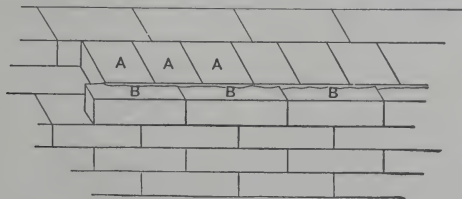
Fig. 78.—Secrete Bond or Headers.

its width and a three-quarter bond course laid behind, as shown. Metal wall ties of various kinds are also used for bonding the

face brick to the main wall. When these are used they should

FIG. 79.—Metal Wall Ties.

be put on about every third or fourth course, or at any course where the face brick and the backing come to the same level, as shown at B, Fig. 79.
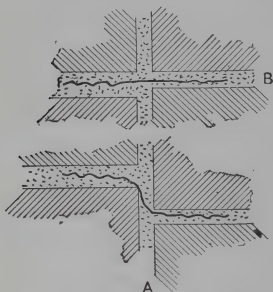
At A, Fig. 79, is shown a very poor way of putting in a wall tie, as it has very little strength when put in this way. At best wall ties are a very poor method of tying the face of a wall to the main structure, and the author cannot recommend their use.

The strongest wall is obtained when header courses are used in the face of the wall. Fig. 80 shows the common form of bond in which a header course is run at intervals of, say, every
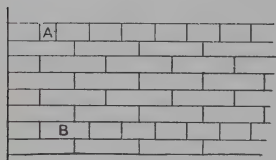
FIG. 80.—Common Bond.
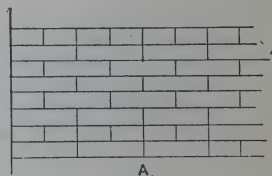
FIG. 81.—Bond Started Wrong.

six courses. This header course should be started with a quarter or three-quarter brick, as shown at A and B, of which that at A looks the best.
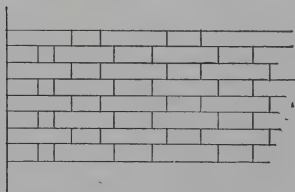
FIG. 82.—Flemish Bond.
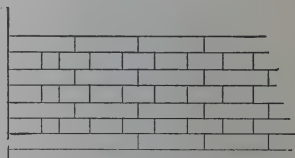
FIG. 83.—English Bond.

Fig. 81 shows the wrong way of starting, and brings three vertical joints over each other, as shown at A.

Fig. 82 shows what is known as Flemish bond, in which every alternate brick is a header. In this style of work every alternate course should have headers of full brick, and not "bats."

Fig. 83 shows English bond in which every alternate course is a header course; in this work every sixth course of brick
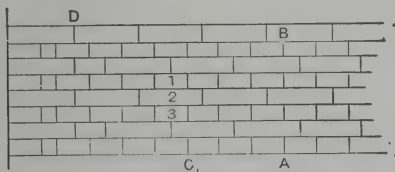
Fig. 84.—English Cross-bond.

should be a full header course. English cross-bond shown by Fig. 84 is similar to the English bond, except that each alternate stretcher course breaks joints with the stretcher course below. This divides the face of the wall up into St. George's crosses, as shown by 1, 2, 3, Fig. 84, and makes a very pleasing appearance to the eye.

Fig. 85 shows how this work should be carried around quoins, etc. In all facework the mason should take great care to keep
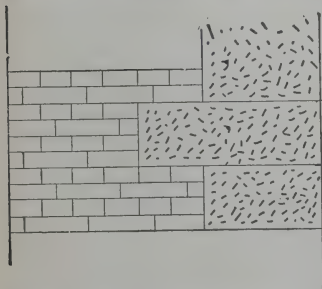
Fig. 85.—English Cross-bond Around Quoins.
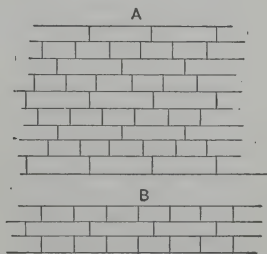
Fig. 86.—Right and Wrong Way of Laying English Cross-bond.

the plumb-joints plumb and in line. Fig. 86 at *A* shows the distorted appearance of a wall laid in English cross-bond, in which the joints were not kept plumb. Fig. 86 at *B* shows the work as it should be.

The author has often found it necessary to have the mason

mark out a pole, as shown by Fig. 87, and mark on it the position of the joints in the stretcher courses; for instance, 1, 1, 1 on the pole will be the position of the joints in one course, and 2, 2, 2 will be the position of the joints in the next stretcher

FIG. 87.—Pole for Laying Out Joints in Brickwork.

course. The pole should be made so that one end of it can be held at the corner of the wall or pier, so that it will always be held in the same position. After the header course is laid the pole should be used and each joint of the stretcher course marked off; after the stretcher is laid the header course can be centred with the eye; then repeat the operation for the next stretcher. The joints should line up, as shown at AB, Fig. 84, and form a true diagonal step, as shown from C to D. When backing up stone ashlar the mason should be careful to get his brick bond to lap on and bond with the stone.

In finishing to the top of a thin course of stone the last course
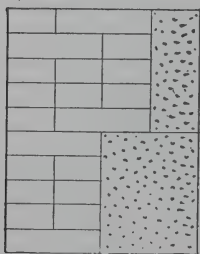
FIG. 88.—Backing Ashlar.
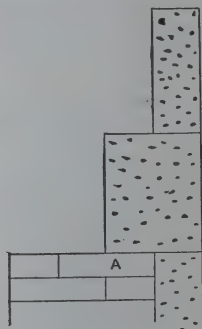
FIG. 89.—Setting Ashlar.

of brick should have a header, as shown at A in Fig. 89, so that the next course of ashlar will lap onto it and form a bond with it.

Never set three or more courses of stone without backing up the brickwork, as shown by Fig. 93. This makes a poor wall. In setting the ashlar it should be set as shown by Fig. 89:

first a thick or bond course, and then a thin one on top, as shown. Then the mason can back up these two courses, as shown by Fig. 88, when the wall will be ready to set two more courses of ashlar.

In turning arch lintels over door or other openings it is customary to use a wood centre, as shown by Fig. 95. The arch
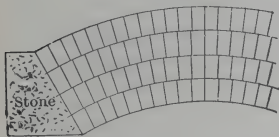
FIG. 90.—Arch of Concentric Rings.
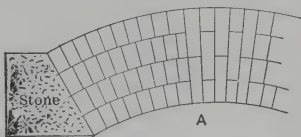
FIG. 91.—Bonded Arch

should be started at the end of the wood centre, as shown by Fig. 95, and not as shown by Fig. 96, as this throws the weight onto the wood.

Arches are usually built of concentric rings or header courses as shown by Fig. 90. Where the arch is to carry a heavy load it is advisable to tie the courses together, as shown at A, Fig. 91. When an arch springs off an outside wall or pier, or where there will be nothing to counteract the thrust of the arch, it is advisable to build in an I beam, as shown by Fig. 92, and have it anchored solid top and bottom with a bolt or rod extending back into the main wall.

CHASES, ETC.—When building walls with recesses or chases for pipes, etc., the mason should use special care to keep these chases straight and plumb and of the same dimensions from bottom to top.

BRACES.—In building long walls without any piers or intersecting walls to tie to they should be well braced temporarily if carried to any height. It requires very little force to cause a "green" wall to sway out of plumb.

FIG. 92.—Thrust-beam in Arch.

HOLLOW WALLS.—In building hollow walls, such as are sometimes built for ventilation, etc., the mason should see that the ties or anchors are put in as often as desired and should

leave holes at the bottom of the wall so the mortar and "bats" can be cleaned out at completion.
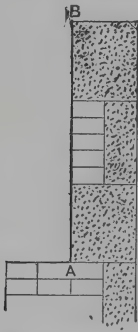
FIG. 93.—Ashlar Set with Bad Bond.
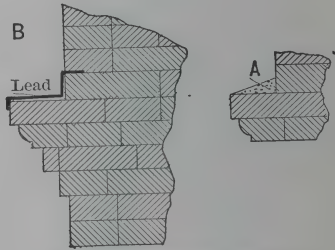
FIG. 94.—Covering Projecting Courses.

PROTECTION OF WALLS.—All brickwork should be covered at night, or at any time when work is suspended, so that in case of rain the mortar will not be washed out before having had time to set.
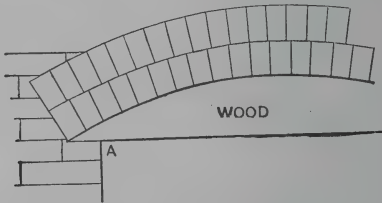
FIG. 95.—Correct Way of Starting Arch.
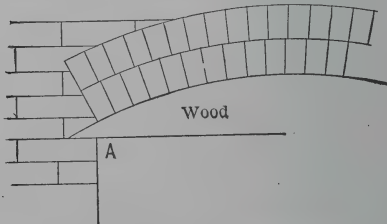
FIG. 96.—Wrong Way of Starting Arch.

Where there are projection courses in the outside wall, they should be covered with lead, as shown by Fig. 94, B; sometimes

they are covered with cement mortar, as shown by Fig. 94, A;
this is not so reliable as the lead, for the cement may crack
and work loose.

CHIMNEYS.—In building chimneys the mason should build
the flues as straight and with as few bends as possible. If in
any case it is necessary to make a short bend in a flue an open-
ing should be left in the chimney at this point to permit of
the flue being cleaned out on completion of the chimney, for if
the bend is very sharp the falling mortar and "bats" will
lodge and obstruct the flue. By leaving an opening this can
be cleaned out and the hole bricked up.

Flues that do not run from a fireplace should have an opening
left at the bottom and a short piece of board inserted to catch
the falling mortar and "bats"; this can be cleaned out and
the hole stopped up on completion of the work.

All joints in the brickwork of a chimney should be filled
solid with mortar, and if the flue-lining is not used the inside
of the flue should be plastered. In former days this was called
"pargetting" and a plaster made of mortar and cow-dung was
used. Portland-cement mortar is the best plaster to use for
this purpose. The top of a chimney above the roof should
be laid in cement mortar. When the chimney is completed, it
is a good idea to have a weight dropped down each flue to make
sure that it is open its entire length, and not stopped up with
"bats" and mortar.
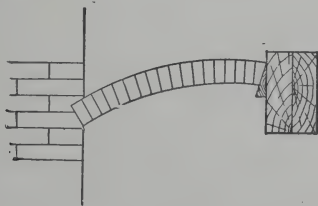
FIG. 97.—Brick Hearth Arch.

The face walls of a building at completion should be washed
down with a solution of diluted muriatic acid and all dirt and
surplus mortar removed; all open joints left under window-
sills, etc., should now be pointed, care being taken to use just
enough mortar to fill the face of the joint.

HEARTH ARCHES.—"Trimmer" or "hearth" arches for the
support of a hearthstone or tile are usually built of brick and

should be built as shown by Fig. 97; this throws the weight
and thrust nearly all on the chimney and not on the wood
joist. A flat wood centre is often used in frame houses, as shown
by Fig. 98; but the author does not consider this a good method,
for the wood in the recess in the brickwork is but $2\frac{1}{2}$ or 3 inches
away from the flue, which is too close for safety. Where centres
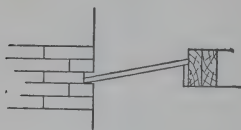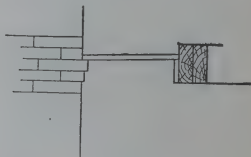
FIG. 98.   FIG. 99.

Wood Hearth Arches.

of this kind are used it is better to corbel out, as shown by
Fig. 99; this will give 4 inches of brick between the wood and
the flue.

BRICK NOGGING.—In wooden partitions it is often specified
for a course of brick to be built in at the bottom of the story,
and also at half-height, resting on the bridging; this is to pre-
vent the passage of vermin and also act as a fire-stop. The
brick-mason should see that the brick used in such cases are
not wider than the studs, so the lathing can be nailed on
straight; where the joist rests on a partition it is well to build
"nogging" from the top of this partition to the top of the joist.

WALLS, PLUGS, AND BLOCKS.—In building walls where metal
nailing-plugs or wooden blocks are built in for nailing purposes
the bricklayer should endeavor to get these blocks or plugs
in as often and at the points designated by the carpenter.
It only requires a little close attenti n on the part of the brick-
mason to get them in where they ought to be, but if left out
or not put in at the right place it means hours of extra work
for the carpenter when he comes to put up his grounds and
trim. The metal nailing-plugs usually have a corrugated out-
side surface and should be bedded in mortar all around, as this
is what holds the plug in the wall. The plug is of no value
if put in the wall dry and nothing to hold it.

LEVELLING OF BRICKWORK.—The various courses of brick at
the corners and leads of brickwork should be kept level, and
the courses then laid to the line, which will bring each course

level. When the walls are started the starting course should be carefully levelled, using a level and straight-edge. After the corners are started and the brickwork is up three or four courses, drive a nail or flat piece of iron in the joint of the level course at each corner or angle, and use a pole to keep the wall level, by setting the pole on this nail or piece of iron, thus keeping the wall the same height from the level or starting-point.

In building chimneys, etc., through a floor of joist, the joist will often be found framed too small for the brickwork, and after passing through the joist the brickwork will have to be set over, as shown at A, Fig. 100. The brickwork should be carried up one or two courses above the joist before setting over or the weight of the brickwork may be thrown on the joist in case of any settlement, as shown at A.
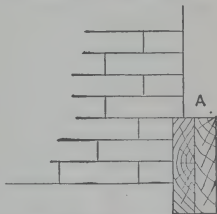
Fig. 100.—Brickwork Resting on Joint.

SETTING WALL-PLATES, BEARING-BLOCKS, ETC.—Wall-plates or bearing-blocks of any kind should always be set as accurately as possible, as the height and level of floors, stories, etc., will depend on the accuracy with which these plates, etc., are set.

A good method by which to set plates, etc., is to nail a wood strip or lath on the wall to one side of where the plate will set and have the foreman of the building mark the exact height of the plate on this strip, as at A, Fig. 101. Where there are a number of plates to set these strips can be put in place and all the heights marked at once.
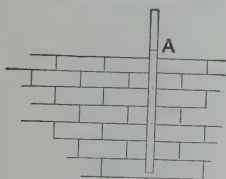
Fig. 101.—Height of Bearing-plates.

On a job where there is an engineer's level or transit this can be done in a very few moments.

Rules for Brickwork.

WALLS, PIERS, AND PARTITIONS.—The following, taken from the New York Building Code, 1901, is a very good guide for the stone- or brick-mason regarding good work:

Sec. 27. *Materials of Walls.*—The walls of all buildings, other than frame or wood buildings, shall be constructed of stone,

brick, Portland-cement concrete, iron, steel, or other hard, incombustible material, and the several component parts of such buildings shall be as herein provided. All buildings shall be inclosed on all sides with independent or party walls.

Sec. 28. *Walls nd Piers.*—In all walls of the thickness specified in this code, the same amount of materials may be used in piers or buttresses. Bearing walls shall be taken to mean those walls on which the beams, girders, or trusses rest. If any horizontal section through any part of any bearing wall in any building slows more than 30 per centum area of flues and openings, the said wall shall be increased 4 inches in thickness for every 15 per centum, or fraction thereof, of flue or opening area in excess of 30 per centum.

The walls and piers of all buildings shall be properly and solidly bonded together with close joints filled with mortar. They shall be built to a line and be carried up plumb and straight. The walls of each story shall be built up the full thickness to the top of the beams above. All brick laid in non-freezing weather shall be well wet before being laid. Walls or piers, or parts of walls and piers, shall not be built in freezing weather, and if frozen, shall not be built upon.

All piers shall be built of stone or good, hard, well-burnt brick laid in cement mortar. Every pier built of brick, containing less than 9 superficial feet at the base, supporting any beam, girder, arch or column on which a wall rests, or lintel spanning an opening over 10 feet and supporting a wall, shall at intervals of not over 30 inches apart in height have built into it a bond-stone not less than 4 inches thick, or a cast-iron plate of sufficient strength and the full size of the piers. For piers fronting on a street the bond-stones may conform with the kind of stone used for the trimmings of the front. Capstones of cut granite or bluestone, proportioned to the weight to be carried, but not less than 5 inches in thickness, by the full size of the pier, or cast-iron plates of equal strength, by the full size of the pier, shall be set under all columns or girders, except where a 4-inch bond-stone is placed immediately below said cap-stone, in which case the cap-stone may be reduced in horizontal dimensions at the discretion of the Commissioner of Buildings having jurisdiction. Isolated brick piers shall not exceed in height ten times their least dimensions. Stone posts for the support of posts or columns above shall not be used in the interior of any building. Where walls or piers

are built of coursed stones, with dressed level beds and vertical joints, the Department of Buildings shall have the right to allow such walls or piers to be built of a less thickness than specified for brickwork, but in no case shall said walls or piers be less than three-quarters of the thickness provided for brickwork.

In all brick walls every sixth course shall be a heading course, except where walls are faced with brick in running bond, in which latter case every sixth course shall be bonded into the backing by cutting the course of the face brick and putting in diagonal headers behind the same, or by splitting the face brick in half and backing the same with a continuous row of headers. Where face brick is used of a different thickness from the brick used for backing, the courses of the exterior and interior brickwork shall be brought to a level bed at intervals of not more than ten courses in height of the face brick, and the face brick shall be properly tied to the backing by a heading course of the face brick. All bearing walls faced with brick laid in running bond shall be 4 inches thicker than the walls are required to be under any section of this Code.

Sec. 29. *Ashlar.*—Stone used for the facing of any building, and known as ashlar, shall be not less than 4 inches thick.

Stone ashlar shall be anchored to the backing and the backing shall be of such thickness as to make the walls, independent of the ashlar, conform as to the thickness with the requirements of sections 31 and 32 of this Code, unless the ashlar be at least 8 inches thick and bonded into the backing, and then it may be counted as part of the thickness of the wall.

Iron ashlar plates used in imitation of stone ashlar on the face of a wall shall be backed up with the same thickness of brickwork as stone ashlar.

Sec. 30. *Mortar for Walls and Ashlar.*—All foundation-walls, isolated piers, parapet walls and chimneys above roofs shall be laid in cement mortar, but this shall not prohibit the use in cold weather of a small proportion of lime to prevent the mortar from freezing. All other walls built of brick or stone shall be laid in lime, cement, or lime and cement mortar mixed.

The backing up of all stone ashlar shall be laid up with cement mortar, or cement and lime mortar mixed, but the back of the ashlar may be pargeted with lime mortar to prevent discoloration of the stone.

Sec. 31. *Walls for Dwelling-houses.*—The expression "walls

for dwelling-houses" shall be taken to mean and include this class walls for the following buildings:

Dwellings, asylums, apartment-houses, convents, club-houses, dormitories, hospitals, hotels, lodging-houses, tenements, parish buildings, schools, laboratories, studios.

The walls above the basement of dwelling-houses not over three stories and basement in height, nor more than 40 feet in height, and not over 20 feet in width, and not over 55 feet in depth, shall have side and party walls not less than 8 inches thick, and front and rear walls not less than 12 inches thick. All walls of dwellings exceeding 20 feet in width and not exceeding 40 feet in height shall be not less than 12 inches thick. All walls of dwellings 26 feet or less in width between bearing-walls which are hereafter erected or which may be altered to be used for dwellings, and being over 40 feet in height and not over 50 feet in height, shall be not less than 12 inches thick above the foundation-wall. No wall shall be built having a 12-inch-thick portion measuring vertically more than 50 feet. If over 50 feet in height and not over 60 feet in height the wall shall be not less than 16 inches thick in the story next above the foundation-walls and from thence not less than 12 inches to the top. If over 60 feet in height, and not over 75 feet in height, the walls shall be not less than 16 inches thick above the foundation-walls to the height of 25 feet, or to the nearest tier of beams to that height, and from thence not less than 12 inches thick to the top. If over 75 feet in height, and not over 100 feet in height, the walls shall be not less than 20 inches thick above the foundation-walls to the height of 40 feet, or to the nearest tier of beams to that height, thence not less than 16 inches thick to the height of 75 feet, or to the nearest tier of beams to that height, and thence not less than 12 inches thick to the top. If over 100 feet in height, and not over 125 feet in height, the walls shall be not less than 24 inches thick above the foundation-walls to the height of 40 feet or to the nearest tier of beams to that height, thence not less than 20 inches thick to the height of 75 feet, or to the nearest tier of beams to that height, thence not less than 16 inches thick to the height of 110 feet, or to the nearest tier of beams to that height, and thence not less than 12 inches thick to the top. If over 125 feet in height and not over 150 feet in height, the walls shall be not less than 28 inches thick above the foundation-walls to the height of 30 feet, or to the nearest

tier of beams to that height; thence not less than 24 inches thick to the height of 65 feet, or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 100 feet, or to the nearest tier of beams to that height; thence not less than 16 inches thick to the height of 135 feet, or to the nearest tier of beams to that height, and thence not less than 12 inches thick to the top. If over 150 feet in height, each additional 30 feet in height or part thereof, next above the foundation-walls, shall be increased 4 inches in thickness, the upper 150 feet of wall remaining the same as specified for a wall of that height.

All non-fireproof dwelling-houses erected under this section, exceeding 26 feet in width, shall have brick fore-and-aft partition-walls. All non-bearing walls of buildings hereinbefore in this section specified may be 4 inches less in thickness, provided however, that none are less than 12 inches thick, except as in this Code specified. 8-inch brick partition-walls may be built to support the beams in such building in which the distance between the main or bearing walls is not over 33 feet; if the distance between the main or bearing walls is over 33 feet the brick partition-wall shall be not less than 12 inches thick; provided, that no clear span is over 26 feet. No wall shall be built having any one thickness measuring vertically more than 50 feet. This section shall not be construed to prevent the use of iron or steel girders, or iron or steel girders and columns, or piers of masonry, for the support of the walls and ceilings over any room which has a clear span of more than 26 feet between walls, in such dwellings as are not constructed fireproof, nor to prohibit the use of iron or steel girders, or iron or steel girders and columns in place of brick walls in buildings which are to be used for dwellings when constructed fireproof. If the clear span is to be over 26 feet, then the bearing-walls shall be increased 4 inches in thickness for every 12½ feet or part thereof that said span is over 26 feet, or shall have, instead of the increased thickness, such piers or buttresses as, in the judgment of the Commissioner of Buildings having jurisdiction, may be necessary.

Whenever two or more dwelling-houses shall be constructed not over 12 feet 6 inches in width, and not over 50 feet in height, the alternating centre wall between any two such houses shall be of brick not less than 8 inches thick above the foundation-wall; and the ends of the floor-beams shall be so separated that

4 inches of brickwork will be between the beams where they rest on the said centre wall.

Sec. 32. *Walls for Warehouses.*—The expression "walls for warehouses" shall be taken to mean and include in this class walls for the following buildings:

Warehouses, stores, factories, mills, printing-houses, pumping-stations, refrigerating-houses, slaughter-houses, wheelwright-shops, cooperage-shops, breweries, light- and power-houses, sugar-refineries, office-buildings, stables, markets, railroad buildings, jails, police-stations, court-houses, observatories, foundries, machine-shops, public assembly buildings, armories, churches, theatres, libraries, museums. The walls of all warehouses 25 feet or less in width between walls or bearings shall be not less than 12 inches thick to the height of 40 feet above the foundation-walls. If over 40 feet in height, and not over 60 feet in height, the walls shall be not less than 16 inches thick above the foundation-walls to the height of 40 feet, or to the nearest tier of beams to that height, and thence not less than 12 inches thick to the top. If over 60 feet in height, and not over 75 feet in height, the walls shall be not less than 20 inches thick above the foundation-walls to the height of 25 feet, or to the nearest tier of beams to that height, and thence not less than 16 inches thick to the top. If over 75 feet in height, and not over 100 feet in height, the walls shall be not less than 24 inches thick above the foundation-walls to the height of 40 feet, or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 75 feet, or to the nearest tier of beams to that height, and thence not less than 16 inches thick to the top. If over 100 feet in height, and not over 125 feet in height, the walls shall be not less than 28 inches thick above the foundation-walls to the height of 40 feet, or to the nearest tier of beams to that height; thence not less than 24 inches thick to the height of 75 feet, or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 110 feet, or to the nearest tier of beams to that height, and thence not less than 16 inches thick to the top. If over 125 feet in height, and not over 150 feet the walls shall be not less than 32 inches thick above the foundation-walls to the height of 30 feet, or to the nearest tier of beams to that height; thence not less than 28 inches thick to the height of 65 feet, or to the nearest tier of beams to that height; thence not less than 24 inches thick to the height of 100 feet,

or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 135 feet, or to the nearest tier of beams to that height; and thence not less than 16 inches thick to the top. If over 150 feet in height, each additional 25 feet in height, or part thereof next above the foundation-walls shall be increased 4 inches in thickness, the upper 150 feet of wall remaining the same as specified for a wall of that height.

If there is to be a clear span of over 25 feet between the bearing-walls, such walls shall be 4 inches more in thickness than in this section specified, for every $12\frac{1}{2}$ feet, or fraction thereof, that said walls are more than 25 feet apart, or shall have instead of the increased thickness such piers or buttresses as, in the judgment of the Commissioner of Buildings, may be necessary.

The walls of buildings of a public character shall be not less than in this Code specified for warehouses with such piers or buttresses, or supplemental columns of iron or steel, as, in the judgment of the Commissioner of Buildings having jurisdiction, may be necessary to make a safe and substantial building.

In all stores, warehouses, and factories over 25 feet in width between walls there shall be brick partition-walls, or girders supported on iron, steel, or wood columns, or piers of masonry.

In all stores, warehouses, or factories, in case iron, steel, or wood girders, supported by iron, steel, or wood columns, or piers of masonry, are used in place of brick partition-walls, the building may be 75 feet wide and 210 feet deep, when extending from street to street, or when otherwise located may cover an area of not more than 8000 superficial feet. When a building fronts on three streets it may be 105 feet wide and 210 feet deep, or if a corner building fronting on two streets it may cover an area of not more than 12,500 superficial feet; but in no case wider nor deeper, nor to cover a greater area, except in the case of fire-proof buildings. An area greater than herein stated may, considering location and purpose, be allowed by the Board of Buildings when the proposed building does not exceed three stories in height.

Sec. 33. *Increased Thicknesses of Walls for Buildings more than 105 feet in Depth.*—All buildings, not excepting dwellings that are over 105 feet in depth, without a cross-wall or proper piers or buttresses, shall have the side or bearing-walls increased in thickness 4 inches more than is specified in the respective sections of this Code for the thickness of walls for every 105

feet, or part thereof, that the said buildings are over 105 feet in depth.

Sec. 34. *Reduced Thickness for Interior Walls.*—In case the walls of any building are less than 25 feet apart, and less than 40 feet in depth, or there are cross-walls which intersect the walls, not more than 40 feet distant, or piers or buttresses built into the walls, the interior walls may be reduced in thickness in just proportion to the number of cross-walls, piers, or buttresses, and their nearness to each other; provided, however, that this clause shall not apply to walls below 60 feet in height, and that no such wall shall be less than 12 inches thick at the top, and gradually increased in thickness by set-offs to the bottom. The Commissioner of Buildings having jurisdiction is hereby authorized and empowered to decide (except where herein otherwise provided for) how much the walls herein mentioned may be permitted to be reduced in thickness, according to the peculiar circumstances of each case, without endangering the strength and safety of the building.

Sec. 35. *One-story Brick Buildings.*—One-story structures not exceeding a height of 15 feet may be built with 8-inch walls when the bearing-walls are not more than 19 feet apart, and the length of the 8-inch bearing-walls does not exceed 55 feet. One-story and basement extensions may be built with 8-inch walls when not over 20 feet wide, 20 feet deep, and 20 feet high to dwellings.

Sec. 36. *Inclosure Walls for Skeleton Structures.*—Walls of brick built in between iron or steel columns, and supported wholly or in part on iron or steel girders, shall be not less than 12 inches thick for 75 feet of the uppermost height thereof, or to the nearest tier of beams to that measurement, in any building so constructed, and every lower section of 60 feet, or to the nearest tier of beams to such vertical measurement, or part thereof, shall have a thickness of 4 inches more than is required for the section next above it down to the tier of beams nearest to the curb-level; and thence downward the thickness of walls shall increase in the ratio prescribed in section 26, this Code.

Sec. 37. *Curtain-walls.*—Curtain-walls built in between piers or iron or steel columns and not supported on steel or iron girders, shall be not less than 12 inches thick for 60 feet of the uppermost height thereof, or nearest tier of beams to that height, and increased 4 inches for every additional section of 60 feet or nearest tier of beams to that height.

Sec. 38. *Existing Party Walls.*—Walls heretofore built for or used as party walls, whose thickness at the time of their erection was in accordance with the requirements of the then existing laws, but which are not in accordance with the requirements of this Code, may be used, if in good condition, for the ordinary uses of party walls, provided the height of the same be not increased.

Sec. 39. *Lining Existing Walls.*—In case it is desired to increase the height of existing party or independent walls, which are less in thickness than required under this Code, the same shall be done by a lining of brickwork to form a combined thickness with the old wall of not less than 4 inches more than the thickness required for a new wall corresponding with the total height of the wall when so increased in height. The said linings shall be supported on proper foundations and carried up to such height as the Commissioner of Buildings having jurisdiction may require. No lining shall be less than 8 inches in thickness, and all lining shall be laid up in cement mortar and thoroughly anchored to the old brick walls with suitable wrought-iron anchors, placed 2 feet apart and properly fastened or driven into the old walls in rows alternating vertically and horizontally with each other, the old walls being first cleaned of plaster or other coatings where any lining is to be built against the same. No rubble wall shall be lined except after inspection and approval by the Department.

Sec. 40. *Walls of Unfinished Buildings.*—Any building, the erection of which was commenced in accordance with specifications and plans submitted to and approved by the Department of Buildings prior to the passage of this Code, if properly constructed, and in safe condition, may be completed, or built upon in accordance with the requirements of law, as to thickness of walls, in force at the time when such specification and plans were approved.

Sec. 41. *Walls Tied, Anchored, and Braced.*—In no case shall any wall or walls of any building be carried up more than two stories in advance of any other wall, except by permission of the Commissioner of Buildings having jurisdiction, but this prohibition shall not include the inclosure walls for skeleton buildings. The front, rear, side and party walls shall be properly bonded together, or anchored to each other every 6 feet in their height by wrought-iron tie anchors, not less than $1\frac{1}{2}$ inches by $\frac{3}{8}$ inch in size, and not less than 24 inches in length.

The side anchors shall be built into the side or party walls not less than 16 inches, and into the front and rear walls, so as to secure the front and rear walls to the side, or party walls, when not built and bonded together. All exterior piers shall be anchored to the beams or girders on the level of each tier. The walls and beams of every building, during the erection or alteration thereof, shall be strongly braced from the beams of each story, and when required, shall also be braced from the outside, until the building is inclosed. The roof tier of wood beams shall be safely anchored, with plank or joist, to the beams of the story below until the building is inclosed.

Sec. 42. *Arches and Lintels.*—Openings for doors and windows in all buildings shall have good and sufficient arches of stone, brick, or terra-cotta, well built and keyed with good and sufficient abutments, or lintels of stone, iron, or steel of sufficient strength, which shall have a bearing at each end of not less than 5 inches on the wall. On the inside of all openings in which lintels shall be less than the thickness of the wall to be supported, there shall be timber lintels, which shall rest at each end not more than 3 inches on any wall, which shall be chamfered at each end, and shall have a suitable arch turned over the timber lintel. Or the inside lintel may be of cast iron, or wrought iron or steel, and in such case stone blocks or cast-iron plates shall not be required at the ends where the lintel rests on the walls, provided the opening is not more than 6 feet in width.

All masonry arches shall be capable of sustaining the weight and pressure which they are designed to carry, and the stress at any point shall not exceed the working stress for the material used, as given in section 139 of this Code. Tie-rods shall be used where necessary to secure stability.

Sec. 43. *Parapet Walls.*—All exterior and division or party walls over 15 feet high, excepting where such walls are to be finished with cornices, gutters, or crown mouldings, shall have parapet walls not less than 8 inches in thickness and carried 2 feet above the roof, but for warehouses, factories, stores, and other buildings used for commercial or manufacturing purposes the parapet walls shall be not less than 12 inches in thickness and carried 3 feet above the roof, and all such walls shall be coped with stone, terra-cotta, or cast iron.

Sec. 44. *Hollow Walls.*—In all walls that are built hollow the same quantity of stone, brick, or concrete shall be used in

their construction as if they were built solid, as in this Code provided, and no hollow wall shall be built unless the parts of same are connected by proper ties, either of brick, stone, or iron, placed not over 24 inches apart.

Sec. 45. *Hollow Bricks on Inside of Walls.*—The inside 4 inches of all walls may be built of hard-burnt hollow brick, properly tied and bonded into the walls, and of the dimension of ordinary bricks. Where hollow tile or porous terra-cotta blocks are used as lining or furring for walls, they shall not be included in the measurement of the thickness of such walls.

Sec. 46. *Recesses and Chases in Walls.*—Recesses for stairways or elevators may be left in the foundation- or cellar-walls of all buildings, but in no case shall the walls be of less thickness than the walls of the fourth story, unless reinforced by additional piers with iron or steel girders, or iron or steel columns and girders, securely anchored to walls on each side. Recesses for alcoves and similar purposes shall have not less than 8 inches of brickwork at the back of such recesses, and such recesses shall be not more than 8 feet in width, and shall be arched over or spanned with iron or steel lintels, and not carried up higher than 18 inches below the bottom of the beams of the floor next above. No chase for water or other pipes shall be made in any pier, and in no wall more than one-third of its thickness. The chases around said pipe or pipes shall be filled up with solid masonry for the space of 1 foot at the top and bottom of each story. No horizontal recess or chase in any wall shall be allowed exceeding 4 feet in length without permission of the Commissioner of Buildings having jurisdiction. The aggregate area of recesses and chases in any wall shall not exceed one-fourth of the whole area of the face of the wall on any story, nor shall any such recess be made within a distance of 6 feet from any other recess in the same wall.

Sec. 47. *Furred Walls.*—In all walls furred with wood the brickwork between the ends of wood beams shall project the thickness of the furring beyond the inner face of the wall for the full depth of the beams.

Sec. 48. *Light and Vent Shafts*—In every building hereafter erected or altered, all the walls or partitions forming interior light or vent shafts, shall be built of brick, or such other fireproof materials as may be approved by the Commissioner of Buildings having jurisdiction. The walls of all light or vent

shafts, whether exterior or interior, hereafter erected, shall be carried up not less than 3 feet above the level of the roof, and the brick walls coped as other parapet walls. Vent shafts to light interior bathrooms in private dwellings may be built of wood filled in solidly with brick or hard-burnt clay blocks, when extending through not more than one story in height, and carried not less than 2 feet above the roof, covered with a ventilating skylight of metal and glass.

Sec. 49. *Brick and Hollow-tile Partitions.*—Eight-inch brick and 6-inch and 4-inch hollow-tile partitions, of hard-burnt clay, or porous terra-cotta, may be built, not exceeding in their vertical portions a measurement of 50, 36, and 24 feet respectively, and in their horizontal measurement a length not exceeding 75 feet, unless strengthened by proper cross-walls, piers, or buttresses, or built in iron or steel framework. All such partitions shall be carried on proper foundations, or on iron or steel girders, or on iron or steel girders and columns or piers of masonry.

Sec. 50. *Cellar Partitions in Residence Buildings.*—One line of fore-and-aft partitions in the cellar or lowest story, supporting stud partitions above, in all residence buildings over 20 feet between bearing-walls in the cellar or lowest story, hereafter erected, shall be constructed of brick, not less than 8 inches thick, or piers of brick with openings arched over below the under side of the first tier of beams, or girders of iron or steel and iron columns, or piers of masonry may be used; or if iron or steel floor beams spanning the distance between bearing-walls are used of adequate strength to support the stud partitions above in addition to the floor load to be sustained by the said iron or steel beams, then the fore-and-aft brick partition, or its equivalent, may be omitted.

Stud partitions which may be placed in the cellar or lowest story of any building shall have good solid stone or brick foundation-walls under the same, which shall be built up to the top of the floor-beams or sleepers, and the sills of said partitions shall be of locust or other suitable hard wood; but if the walls are built 5 inches higher of brick than the top of the floor-beams or sleepers, any wooden sill may be used on which the studs shall be set.

Sec. 51. *Main Stud Partitions.*—In residence buildings where fore-and-aft stud partitions rest directly over each other, they shall run down between the wood floor-beams and rest on the

top plate of the partition below, and shall have the studding filled in solid between the uprights to the depth of the floor-beams with suitable incombustible materials.

Sec. 52. *Timber in Walls Prohibited.*—No timber shall be used in any wall of any building where stone, brick, or iron is commonly used, except inside lintels, as herein provided, and brace blocks not more than 8 inches in length.

POINTING.—Fig. 102 shows different styles of pointing used in face brickwork, that shown at *I* being the most common, or what is known as the struck joint; it is made with the point of the trowel, using the lower course of brick to rest the trowel on, and the top course as a guide for drawing the trowel along.

Some architects object to this style of joint, claiming the small projection on the lower course forms a table to catch the water, and preferring that shown at *K*, which is just the reverse of that at *I*. The author has used both, and for looks prefers that shown at *I*, for this reason: A person standing on the ground and looking up at a wall with joints struck as shown at *K*, the eye will catch the little projection on every course of brick and cause the wall to look rough, but with the method shown at *I*, the projections cannot be seen and the wall looks perfectly smooth to the eye.

The pointing-trowel should be held with the blade nearly vertical so as to strike the joint as shown at *I*, and not at as great an angle as shown at *J*. This method shown at *A* is much used in press-brick work, being a combination of the methods shown at *I* and *K*. The joint shown at *D* is made by using an iron rod the thickness of the joint; this is laid on the face edge of the brick already laid and the mortar spread out to it; after the bricks are laid and the mortar has sufficiently hardened the rod is taken out and the mortar smoothed, if necessary, with a tool. It takes several rods, as the mason will lay up several courses before the mortar is hard enough to permit the rod to be taken out. The rest of the joints shown are made with a jointing-tool of the desired shape.

[1] **Efflorescence on Brick Walls.**—It is a well-known fact that the appearance of brickwork is often greatly marred by the efflorescence which shows upon its surface, and various have been the efforts to ascertain some means or process by which the difficulty could be remedied. One of the latest

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[1] Carpentry and Building.

investigators into the causes of efflorescence is J. C. Jones of the University of Illinois, who has been looking into the matter and finds the unsightly appearance of brickwork to be due to the following: 1. Soluble salts contained in the clay as mined. 2. Soluble salts developed in the clay by weathering. 3.
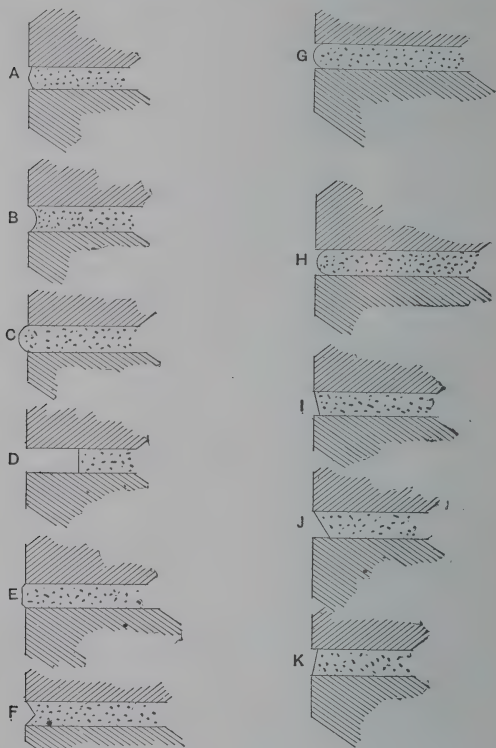
Fig. 102.—Styles of Pointing for Brickwork.

Soluble substances formed in the clay during burning, partly by chemical changes among the ingredients of the clay itself and partly by interaction between the materials of the clay and the kiln-gases. 4. Soluble salts in the mortar used to bind the bricks in the wall. 5. Soluble substances developed by reactions between the ingredients of the mortar and those

of the clay.   6. Soluble salts in the water used in the manu-
facture of brick or mortar.   7. Soluble salts in the soil or sub-
stances lying against the wall.

He finds that efflorescence usually is made up of sulphates
and carbonates, with occasionally salts of other acids which
are carried to the surface of the bricks by the evaporation of
water which has entered them.

The suggested cures are: 1. The use of clay which has not
been weathered.   2. To weather the clay and then wash out
all soluble salts.   3. To change soluble into insoluble salts by
introducing some precipitating agent, as barium.   4. To re-
move efflorescence which has been formed in the kiln by alter-
nating oxidizing with reducing conditions during the latter part
of the burn.   5. To coat the bricks as they come from the
machine with some organic substance.   6. To burn the bricks
so that they will absorb the smallest possible amount of water.
7. To coat those portions of the wall below the ground with
water-proof paint.   8. To see that the gutters and flues which
carry water- or steam-pipes are so constructed that water
cannot reach the walls.   9. To make mortar joints as thin as
possible and use mortar which is free from sulphur or nearly so.

Terra-cotta Work.

SETTING HOLLOW-TILE FIREPROO ING.—This work is usually
done by the brick-mason, although some men can set tile who
cannot lay brick, as both must be learned by practice and
experience.   The main points to be observed in setting tile
are to see that there is a good joint of
mortar between all parts of adjoining
tiles and that the different webs of ad-
joining tiles butt fairly against each
other.   Fig. 103 shows how by careless
workmanship tiles are sometimes set so
that the webs of the adjoining tiles over-
lap and they do not have a true bearing
against each other.

FIG. 130.—Overlapping
of Floor-tiles.

This makes very weak construction and
care should always be taken to get the
tiles to butt solid against each other.

SETTING TILE.—In setting the tile of floor arches the side
of the beam should first be given a heavy coat of mortar, and

the skew-back tile should be coated on the end which sets against the beam and the tile shoved into place. The succeeding tile should then be coated with mortar on one end and side and shoved into place so as to obtain a solid joint of about $\frac{3}{8}$ inch, as this size joint is heavy enough for all tilework. The tile used should be of such a size that the key will just fill the space intended with the above size joints. It should not be so tight that it has to be driven or forced home.

If the joints are a little large they can be wedged with flat pieces of tile or slate, but if the proper size tiles are used this will not be necessary.

In setting floor or arch tile the setter should finish the arch as he goes along, that is, finish each course of tile across the arch and insert the key before starting another course of tile.

When tile of the side construction are used and the tiles overlap and break joints the courses can be stepped back and the key put in place. This method gives the setter a better chance to get the joints slushed full of mortar and also prevents the wooden centre from sagging with the weight of the tile, which is the case when the tiles are all put in and the keys left out until the last.

All tile whether dense or porous should be thoroughly wet with water just before being set, or the suction of the tile will suck the water from the mortar and cause it to lose its strength.

When the tiles are set in freezing weather they must of course be set dry, but it is best not to set any tile when the water or mortar will freeze.

Some setters set wall-tile with the webs running horizontal, but this is not the way they are intended to be set. It is an easier way to set them, but does not make as strong a wall as if the webs run perpendicular.

Tiles are often built against brick walls for furring, etc., and when setting such tile the setter should anchor them as often as necessary by driving spikes into the joints of the brickwork i such a way that the head of the spike can be built in the joints of the tile.

MORTAR FOR SETTING TILE.—The mortar for setting hollow-tile should be a cement mortar. One part of natural cement to two parts sand make a very good mortar for setting terra-cotta tilework. After a tile arch is completed it is a good idea to spread a thin coat of mortar over the arch, as this is a good protection to the tile and fills up any crevices.

Setting Ornamental Terra-cotta.—Terra-cotta is usually set by the brick-mason, who should be very careful in setting it to give it a solid bearing in the bed of mortar. If there is to be any weight put on top of it he should fill the hollow part of the block with brick and mortar. If the terra-cotta has not enough bond in the wall to insure it being held firmly in place it should be anchored with galvanized wire or anchors.

All the joints should be filled and neatly pointed with cement mortar, and all running courses set to a true line.

As soon as any terra-cotta is set and the work to be carried on above, the terra-cotta should be covered to protect it from being broken by falling brick, etc.

Estimating Brickwork.

Brickwork is estimated at the rate of a brick and a half thick. Therefore if a wall be more or less than this standard of thickness it must be reduced to it as follows:

Rule.—Multiply the superficial contents of the wall by the number of half-bricks in the thickness and one-third of that product will be the contents required.

Example.—How many bricks will it require to build a house 30 feet square, 20 feet high, and 12 inches thick above which is a triangular gable rising 12 feet and 8 inches thick?

$$30 \times 6 = 180 = 1 \text{ gable end}$$
$$30 \times 6 = 180 = 1 \text{ gable end}$$
$$\overline{\qquad\qquad}$$
$$360 \times 15 = \dots\dots\dots \quad 5,400$$
$$30 + 30 = 60 = \text{two side walls}$$
$$28 + 28 = 56 = \text{two end walls}$$
$$\overline{\qquad}$$
$$116$$
$$20 = \text{height}$$
$$\overline{\qquad\qquad}$$
$$2320 \times 22\tfrac{1}{2} = \dots\dots\dots \quad 52,200$$
$$\overline{\qquad\qquad\qquad}$$
$$57,600 \ (Ans.)$$

One barrel lime will lay 1000 to 1200 bricks.

One man with one tender will lay 1000 to 1500 bricks per day.

One thousand bricks closely stacked occupy 56 cubic feet.

One thousand old bricks cleaned and loosely stacked occupy about 70 cubic feet.

Six hundred bricks, 1 cubic yard in wall.

One barrel of Portland cement to 2 sand will lay about 750 brick with $\frac{3}{8}$-inch joint.

One barrel of Portland cement to 3 of sand will lay about 1050 brick with $\frac{1}{4}$-inch joint.

One barrel of Portland cement to 3 of sand will lay about 900 brick with $\frac{3}{8}$-inch joint.

One barrel of Portland cement to 3 sand will lay about 1350 brick with $\frac{1}{4}$-inch joint.

NUMBER OF BRICKS REQUIRED FOR CHIMNEYS.—To find the number of bricks required to build a chimney, find the number of cubic feet in the entire chimney and subtract the contents of the flues as follows:

If 8-inch flues subtract one-half the length of the flue in feet.

If 12-inch flues subtract the length of the flue in feet.

If 18-inch flues subtract $2\frac{1}{4}$ times the length of the flue in feet.

If 24-inch flues subtract four times the length of the flue in feet.

Multiply the answer by 20, which will give the number of bricks required to build the chimney.

TABLE TO FIND THE NUMBER OF BRICKS IN ANY WALL.

Super-ficial Feet of Wall.	Number of Bricks to Thickness of Wall.					
	4-inch.	8-inch.	12-inch.	16-inch.	20-inch.	24-inch.
1	$7\frac{1}{2}$	15	23	30	38	45
2	15	30	45	60	75	90
3	23	45	68	90	113	135
4	30	60	90	120	150	180
5	38	75	113	150	188	225
6	45	90	135	180	225	270
7	53	105	158	210	263	315
8	60	120	180	240	300	300
9	68	135	203	270	338	405
10	75	150	225	300	375	450
20	150	300	450	600	750	900
30	225	450	675	900	1,125	1,350
40	300	600	900	1,200	1,500	1,800
50	375	750	1,125	1,500	1,875	2,250
60	450	900	1,350	1,800	2,250	2,700
70	525	1,050	1,575	2,100	2,625	3,150
80	600	1,200	1,800	2,400	3,000	3,600
90	675	1,350	2,025	2,700	3,375	4,050
100	750	1,500	2,250	3,000	3,750	4,500
200	1,500	3,000	4,500	6,000	7,500	9,000
300	2,250	4,500	6,750	9,000	11,250	13,500
400	3,000	6,000	9,000	12,000	15,000	18,000
500	3,750	7,500	11,250	15,000	18,750	22,500
600	4,500	9,000	13,500	18,000	22,500	27,000
700	5,250	10,500	15,750	21,000	26,250	31,500
800	6,000	12,000	18,000	24,000	30,000	36,000
900	6,750	13,500	20,250	27,000	33,750	40,500
1,000	7,500	15,000	22,500	30,000	37,500	45,000

TABLE OF NUMBER OF BRICKS REQUIRED IN A WALL PER SQUARE FOOT OF FACE OF WALL.

4 inches	7½	24 inches	45
8 "	15	28 "	52½
12 "	22½	32 "	60
16 "	30	36 "	67½
20 "	37½	40 "	75

Example.—Find the number of bricks in a wall 8 inches thick, 5 feet high, and 10 feet long; five multiplied by ten equals 50 feet of wall 8 inches thick. Under 8 inches and opposite 50 you will find 750, the number of bricks in the wall.

The above tables are based on the usual sizes of Eastern brick; Western brick are made some larger and will take a slight percentage less than in the above tables.

SIZE OF BRICK PIERS AND NUMBER OF BRICKS REQUIRED.

Size of Pier in Inches.	Number of Bricks to Each Foot in Height.	Size of Pier in Inches.	Number of Bricks to Each Foot in Height.	Size of Pier in Inches.	Number of Bricks to Each Foot in Height.
8½ × 8½	8	22 × 30½	70	35 × 52½	192
8½ × 13	12	22 × 35	80		
8½ × 17½	16	22 × 39½	90	39½ × 39½	162
8½ × 22	20			39½ × 44	180
8½ × 26½	24	26½ × 26½	72	39½ × 48	198
		26½ × 30½	84	39½ × 52½	216
13 × 13	18	26½ × 35	96	39½ × 57	234
13 × 17½	24	26½ × 39½	108		
13 × 22	30	26½ × 44	120	44 × 44	200
13 × 26½	36			44 × 48	220
13 × 30½	42	30½ × 30½	98	44 × 52½	240
		30½ × 35	112	44 × 57	260
17½ × 17½	32	30½ × 39½	126	44 × 61	280
17½ × 22	40	30½ × 44	140		
17½ × 26½	48	30½ × 48	154	48 × 48	242
17½ × 30½	56			48 × 52½	264
17½ × 35	64	35 × 35	128	48 × 57	286
		35 × 39½	144	48 × 61	308
22 × 22	50	35 × 44	160	48 × 65½	330
22 × 26½	60	35 × 48	176		

SIZE AND NUMBER OF BRICKS REQUIRED FOR EACH SQUARE FOOT OF PAVING-BRICK.

Size of Brick.	Number Required for Each Sq. Foot.		Size of Brick.	Number Required for Each Sq. Foot.	
	Laid on Edge.	Laid on Flat.		Laid on Edge.	Laid on Flat.
2 × 4 × 8	9	4.5	3 × 4½ × 9	5.3	3.5
2¼ × 4½ × 8½	7.7	4.1	4 × 4 × 8	4.5	4.5
2½ × 4½ × 8½	6.7	3.7	4 × 4 × 9	4	4
2½ × 4½ × 9	6.4	3.5	4½ × 4½ × 8½	3.7	3.7
3 × 4 × 8	6	4.5	4½ × 4½ × 9	3.5	3.5
3 × 4½ × 8½	5.6	3.7			

NUMBER OF BRICK REQUIRED FOR CISTERNS.

Capacity and Number of Cubic Feet in Excavation to Each Foot of Depth.

Diameter of Cistern in Feet.	Depth in Feet.	Thickness of Wall Around Sides.	Number of Bricks in Wall Around Sides.	Number of Bricks in Bottom Laid Flat.	Number of Bricks in Top Arch, 4 Inches Thick.	Number of Bricks in Top Arch, 8 Inches Thick.	Square Feet of Plaster on Top and Bottom.	Sq. Ft. of Plaster on Side to Each Foot of Height.	Cu. Ft. of Excavation to each Foot of Depth.	Contents of Cistern to Each Foot of Depth in Gallons.
4	1	4	82	50	150	320	27	12.5	20	94
4	1	8	170	50	150	320	27	12.5	28	94
5	1	4	109	78	200	425	41	15.70	28	147
5	1	8	225	78	200	425	41	15.70	38	147
6	1	4	130	112	275	600	59	18.85	38	212
6	1	8	275	112	275	600	59	18.85	50	212
7	1	4	154	152	375	790	80	21.99	50	288
7	1	8	319	152	375	790	80	21.99	63	288
8	1	4	175	200	485	1000	105	25.13	63	375
8	1	8	365	200	485	1000	105	25.13	78	375
9	1	8	430	255	600	1250	135	28.27	78	476
9	1	12	615	255	600	1250	135	28.27	95	476
10	1	8	475	314	730	1525	165	31.41	113	585
10	1	12	680	314	730	1525	165	31.41	132	585
11	1	8	520	380	870	1800	200	34.55	132	710
11	1	12	740	380	870	1800	200	34.55	153	710
12	1	12	876	452	1025	2125	240	37.69	176	847
13	1	12	880	530	1175	2425	280	40.84	201	992
14	1	12	940	616	1350	2800	330	43.98	226	1153
15	1	12	1000	705	1550	3200	375	47.12	254	1340

To find the number of bricks required for a cistern: In the table opposite the required diameter find the number of bricks required per foot for the desired thickness of wall and multiply by the desired height of the cistern in feet. To this add the number required for the bottom and top.

The top should have a spring of about one-fifth the diameter. To reduce the capacity of the cistern to barrels divide by 31.5.

Size, etc., of Paving-brick.— Paving-brick vary in size as much if not more than the common building-brick, therefore the size of the brick must be known to estimate correctly the number required for any particular piece of work.

The following table gives the various sizes and number of bricks required for each square foot of paving

NUMBER OF BRICKS AND BARRELS OF CEMENT REQUIRED IN BUILDING CIRCULAR SEWERS, ETC.

TABLE OF BRICK IN CIRCULAR SEWERS ONE FOOT IN LENGTH AND FOUR INCHES OR ONE RING THICK.

Diameter of sewer, feet	2	2½	3	3½	4	5
Number of brick	42	53	63	73	83	105
Barrels of cement per 100 lineal feet	9	11	13	15	17	20

TABLE OF BRICK IN CIRCULAR SEWERS ONE FOOT IN LENGTH AND EIGHT INCHES OR TWO RINGS THICK.

Diameter of sewer, feet	2	2½	3	3½	4	5	6	8	10
Number of brick	115	150	170	195	215	230	305	395	480
Barrels of cement per 100 lin. feet	17	19	22	25	27	34	40	60	75

TABLE OF BRICK IN EGG-SHAPED SEWERS ONE FOOT IN LENGTH AND EIGHT INCHES OR TWO RINGS THICK.

Inside dimensions, feet	2×3	2⅛×3¼	2¼×3½	2½×3¾	2⅔×4	3×4½	3½×5¼	4×6	5×7½
No. of brick	145	160	170	178	185	205	235	260	315
Barrels of cement per 100 lineal feet	19	21	22	23	25	27	34	38	41

NUMBER OF BRICKS IN FLUSHTANKS.
(With 12-inch walls.)

Inside Diameter.	Depths in Feet.				
	5	6	7	8	9
4 feet	1124	1344	1560	1780	2000
5 feet	1417	1680	1940	2200	2460
6 feet	1820	2440	3060	3680	4300

NUMBER OF BRICK IN MANHOLES—DEPTHS BELOW BOTTOM OF COVER.

Diameter, Feet.	Height in Feet.							
	4	5	6	7	10	12	15	20
3.5	677	835	980	1125	1555	1845	2279	3007
4.0	740	880	1030	1180	1625	1948	2410	3180
4.5	830	1040	1190	1370	1910	2270	2826	3730

The above is only approximate, as the sides of flushtanks and manholes have various tapers.

Flushtanks, manholes, etc., will require about 1¾ barrels of cement per 1000 brick.

MATERIALS REQUIRED FOR BRICKWORK OF TUBULAR BOILERS.

SINGLE SETTING.

Boilers.	Common Brick.	Fire-brick.	Sand, Bushels.	Cement, Barrels.	Fire-clay, Pounds.	Lime, Barrels.
30 in. × 8 ft.	5,200	320	42	5	192	2
30 in. × 10 ft.	5,800	320	46	5½	192	2¼
36 in. × 8 ft.	6,200	480	50	6	288	2½
36 in. × 9 ft.	6,600	480	53	6½	288	2¾
36 in. × 10 ft.	7,000	480	56	7	288	3
36 in. × 12 ft.	7,800	480	62	8	288	3¼
42 in. × 10 ft.	10,000	720	80	10	432	4
42 in. × 12 ft.	10,800	720	86	11	432	4¼
42 in. × 14 ft.	11,600	720	92	11¾	432	4½
42 in. × 16 ft.	12,400	720	99	12½	432	5
48 in. × 10 ft.	12,500	980	100	12½	590	5¼
48 in. × 12 ft.	13,200	980	108	13½	590	5½
48 in. × 14 ft.	14,200	980	116	14½	590	5¾
48 in. × 16 ft.	15,200	980	124	15¼	590	6
54 in. × 12 ft.	13,800	1,150	108	13¾	690	5½
54 in. × 14 ft.	14,900	1,150	117	15	690	6
54 in. × 16 ft.	16,000	1,150	126	16	690	6½
60 in. × 10 ft.	13,500	1,280	108	13½	768	5½
60 in. × 12 ft.	14,800	1,280	118	14¾	768	6
60 in. × 14 ft.	16,100	1,280	128	16	768	6½
60 in. × 16 ft.	17,400	1,280	140	17½	768	7
60 in. × 18 ft.	18,700	1,280	148	18¾	768	7½
66 in. × 16 ft.	19,700	1,400	157	19¾	840	8
66 in. × 18 ft.	21,000	1,400	168	21	840	8½
72 in. × 16 ft.	20,800	1,550	166	20¾	930	8½
72 in. × 18 ft.	22,000	1,550	175	22	930	9

TWO BOILERS IN A BATTERY.

Boilers.	Common Brick.	Fire-brick.	Sand, Bushels.	Cement, Barrels.	Fire-clay, Pounds.	Lime, Barrels.
30 in. × 8 ft.	8,900	640	70	9	384	3½
30 in. × 10 ft.	9,600	640	76	9½	384	4
36 in. × 8 ft.	10,500	960	84	10½	576	4¼
36 in. × 9 ft.	11,100	960	88	11	576	4½
36 in. × 10 ft.	11,800	960	95	12	576	4¾
36 in. × 12 ft.	13,000	960	104	13	576	5¼
42 in. × 10 ft.	17,500	1,440	140	17½	864	7
42 in. × 12 ft.	18,600	1,440	148	18½	864	7½
42 in. × 14 ft.	19,900	1,440	159	20	864	8
42 in. × 16 ft.	21,200	1,440	168	21	864	8½
48 in. × 10 ft.	21,400	1,960	170	21½	1,180	8¾
48 in. × 12 ft.	22,300	1,960	178	22⅓	1,180	9
48 in. × 14 ft.	23,900	1,960	190	24	1,180	9½
48 in. × 16 ft.	25,100	1,960	200	25	1,180	10
54 in. × 12 ft.	23,300	2,300	186	23⅓	1,380	9¼
54 in. × 14 ft.	24,800	2,300	198	25	1,380	10
54 in. × 16 ft.	26,300	2,300	210	26½	1,380	10½
60 in. × 10 ft.	22,600	2,560	180	22½	1,536	9
60 in. × 12 ft.	24,800	2,560	198	25	1,536	10
60 in. × 14 ft.	26,800	2,560	214	27	1,536	10¾
60 in. × 16 ft.	28,900	2,560	230	29	1,536	11½
60 in. × 18 ft.	31,000	2,560	218	31	1,536	12½
66 in. × 16 ft.	33,100	2,800	264	33	1,680	13¼
66 in. × 18 ft.	36,500	2,800	276	35	1,680	14
72 in. × 16 ft.	34,000	3,100	272	34	1,860	13¾
72 in. × 18 ft.	38,000	3,100	282	36	1,860	15

MATERIALS REQUIRED FOR BRICKWORK OF FIRE-BOX BOILERS, 12-INCH WALLS.

SINGLE SETTING.

Boilers.	Brick, Number.	Sand, Bushels.	Cement, Barrels.	Lime, Barrels.
30 in. × 6½ ft.	2400	20	2½	1
30 in. × 7½ ft.	2650	21	2½	1
30 in. × 8½ ft.	2900	23	2¾	1¼
36 in. × 7½ ft.	3150	25	3	1½
36 in. × 9 ft.	3550	28	3½	1¾
36 in. × 10½ ft.	4000	31	4	2
42 in. × 8½ ft.	4000	31	4	2
42 in. × 10 ft.	4000	38	5	2¼
42 in. × 11½ ft.	5100	41	5½	2¼
48 in. × 10½ ft.	4900	40	5½	2½
48 in. × 12 ft.	5400	43	5¾	2½
48 in. × 13½ ft.	5800	46	6	2¾
54 in. × 14 ft.	6900	54	6¾	3
54 in. × 16½ ft.	7500	59	7¾	3½

MATERIALS REQUIRED FOR BRICKWORK OF FIRE-BOX BOILERS, 9-INCH WALLS.

SINGLE SETTING.

Boilers.	Brick, Number.	Sand, Bushels.	Cement, Barrels.	Lime, Barrels.
30 in. × 6½ ft.	1640	14	1½	1
30 in. × 7½ ft.	1820	15	1¾	1
30 in. × 8½ ft.	1980	16	2	1¼
36 in. × 7½ ft.	2240	18	2¼	1½
36 in. × 9 ft.	2520	20	2¾	1¾
36 in. × 10½ ft.	2870	23	3	2
42 in. × 8½ ft.	2870	23	3	2
42 in. × 10 ft.	3400	27	3½	2¼
42 in. × 11½ ft.	3800	30	4	2¼
48 in. × 10½ ft.	3600	29	3¾	2¼
48 in. × 12 ft.	3860	30	4	2½
48 in. × 13½ ft.	4140	33	4½	2¾
54 in. × 14 ft.	5150	41	5½	3
54 in. × 16½ ft.	5550	43	5¾	3¼

Size, etc., of Fire-brick.—A 9-inch fire-brick (straight) weighs 7 pounds and contains 100 cubic inches. Six 9-inch bricks will make 1 square foot of face wall. Fifty-four 9-inch bricks will make 1 square yard of face wall.

Street-paving.

Brick Street-paving.— As this is a part of brickwork, and may at times come within the province of the brick-mason, the following specifications prepared by the National Paving-brick Manufacturers' Association are given:

SECTION OF BRICK PAVING
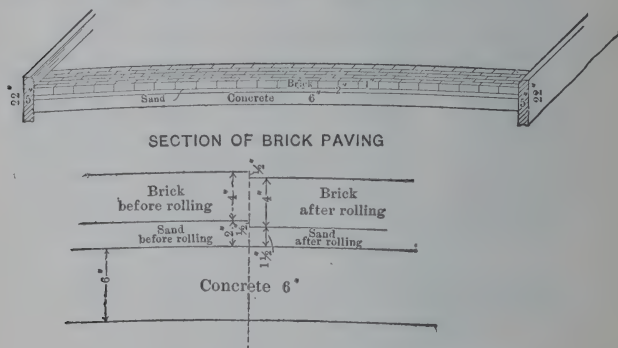
Fig. 104.—Typical Plan of Brick Street-paving.

DIRECTIONS FOR LAYING BRICK STREET PAVEMENTS

Form Two.
Specification One. } Best Known Construction.

Section 1. Substructure or Grading.—Earth in excavation to be removed with plow and scraper or other device, to within two (2) inches of subgrade, then brought to the true grade with the roller, the weight of which should not be less than five (5) nor more than eight (8) tons. If the earth is too hard to receive compression through the roller, then loosen the remaining inches with a pick and cart away.

Earth in embankment must be applied in layers of eight (8) inches in thickness and each layer thoroughly rolled, and in both excavation and embankment the subgrade must have a uniform density.

If the ground is spouty clay, tile drainage should be provided to carry off this accumulation of wet.

Reasons Why.—The attempt to remove earth to the proper depth of grade-line with plow and scraper is usually fatal to the general surface of the subgrade, for the reason that no man can hold a plow or team draw the same to a straight grade, therefore in an attempt to get too close to subgrade with a plow, holes will be gouged below the true grade. When the shovellers commence the removal of the plowed earth, they will invariably sink these same low places still lower, and when the finishing begins these low places will necessarily have to be filled and compacted with the roller. Then you have different characters of solidity, which are objectionable and detrimental to good work.

The prime reason for not using a roller weighing more than eight (8) tons is that it is cumbersome and unwieldy and very slow-moving, while with a lighter and quick-moving one you pass many times over the subgrade and get better results in having your subgrade more uniformly compacted.

The filling with loose earth of portions of the work that is below grade will be found necessary very often if an attempt is made to plow too close to the grade-line; then the lighter roller is found more effective in bringing such places to the same density as the undisturbed portion.

When embankment is necessary to bring the street to the required grade-line, it is very obvious that the earth should be deposited in equal layers of not more than eight (8) inches thick and each layer thoroughly rolled. A six- or eight-ton, or even a heavier, roller will have little effect in compressio below eight inches, and all embankments should be compacted as thoroughly as possible before applying the superstructure; for earth once disturbed and removed from its natural bed takes a long time to acquire its original solidity, the scientific reason for which would take too much space and time to enter upon here.

Underdrainage is not an absolute essential, but in wet and spouty understratum much is added to the durability of the structure by keeping the sub-foundation dry, and under foregoing wet conditions underdrainage is the only way to accomplish the best results.

Section 2. Curbing.—Stone curbing should all be hauled and distributed and set before the grading is finished, and may then be used as a guide to finish the subgrade.

It should range in thickness from four (4) to six (6) inches, twenty (20) to thirty-six (36) inches wide, the business and street traffic governing the same, and lengths not shorter than four (4) feet, except at closures Neatly dressed on top with

a sqaure or rounded edge, and four (4) inches down on the inside. The outer surface to be tool-dressed to the depth of the face exposed and to the depth of the thickness of the brick and sand cushion. If cement-concrete curb is used, it should be completed before the work of finishing the subgrade begins. Curb corners of streets and alleys should be made circular.

Extra Mention.—If concrete curb and gutter is used it must be placed in position before any of the other work is commenced, except possibly some of the heavier grading, and it is essential, if natural stone curb is used, to have it all in place before any portion of the grading is finished, for the reason that, after you have finished a subgrade and given it the proper contour and surface it should never be disturbed by unnecessary wheelage, and nothing destroys it so effectually as hauling heavy stone curb over it; and in renewing these broken places they are rarely returned to the original conditions.

The curb should all be set before the finishing of the subgrade begins, if for no other reason than it affords the very best guide for the said finishing.

SECTION 3. MARGINAL CURB.—Should always be of a hard and durable character of stone and from fourteen (14) to eighteen (18) inches deep, dressed on top, and five (5) inches down on the face next to the brick. Set to accurately fit the curvature of the cross-section of the street on six (6) inches of concrete and backed up with the same within six (6) inches of the top.

Extra Mention.—Marginal curb should always be of a hard and durable character of stone (hard wood is better than soft stone), and set on and backed up with a good Portland-cement concrete, mixed in the proportion of one to two to four.

Marginal curb is as a rule used to sustain a paved street against one that is unpaved, therefore the reason it should be well and properly set, and unless it is the impact of the wheelage in passing from the unpaved to the paved street will soon drive it down and loosen it if it is not firmly and securely set, and in a short time the pavement begins to break and give way and will continue to do so for quite a distance into the intersection.

Even with the marginal curb set in the above manner there should be a margin of crushed stone or clean gravel to the width of three or four feet and eight (8) or ten (10) inches deep spanning the width of the opposing unpaved street and tamped firmly against the marginal curb. With these precautions you will avoid the usual rapid destruction of the margin of your paved streets.

SECTION 4. CONCRETE FOUNDATION.—Should be of approved quality of hard rock, free from all refuse and foreign matter, with no fragment larger than will pass through a two (2) inch ring, and no smaller than will pass through a one ( ) inch ring in their longest dimensions.

Clean, sharp, dry sand, thoroughly mixed in its dry state with an approved brand of either hydraulic or Portland cement until the whole mass shows an even shade. If hydraulic, the proportion of mixture should be one part of cement and two parts of sand. If of Portland, one part of cement to three parts of sand.

To the above mixture should be added sufficient clean water to mix to a plastic mass, fluid enough to rapidly subside when attempting to heap into a cone shape. To this mixture add four (4) and six (6) parts, respectively, of damp crushed stone, or good gravel carrying sufficient sand to make the mixture, and turn the whole mass over not less than three (3) times, or until every fragment is thoroughly coated with the cement mixture. For the reception of this mixture the grade should be set off in five foot-squares, with a stake at each corner. Tops of each should be at the surface of concrete, which must be tamped, until free mortar appears at the surface. Occasional sprinkling in extra-hot, dry weather is beneficial. After thirty-six hours the cushion sand may be spread.

Extra Mention.—If the combination of gravel and sand is used the mixture for natural cement should be one (1) measure of cement to six (6) measures of the mixture. If Portland cement, one (1) measure of cement to eight (8) measures of the mixture.

There is but one way to make good cement mixtures, presuming, of course, you have good material, and that is to thoroughly mix the dry materials. It is essential that the sand and cement should be thoroughly incorporated in this dry state, if not then it can't be done after the water is applied. In the first, you will have a homogeneous mass; in the second, a heterogeneous. In the one your mixture is complete and your structure is uniform; in the other, it varies and your structure is uncertain. The above applies especially to platform mixing. In machine manipulation the dry mixing is not so readily obtainable, but could be more nearly approached if greater care were taken. Thorough mixing in both dry and wet state, with good material and proper proportions, insure a good concrete, whether it be of crushed stone or gravel.

SECTION 5. SAND CUSHION.—Sand should be clean and free from foreign or loamy matter. It need not necessarily be sharp.

It should be two (2) inches thick before the compression of the brick by rolling. The sand should be spread by the aid of a template the whole or one half the width of the street, and made to conform with the true curvature of the street cross-section.

Extra Mention.—The preparation of the subgrade having been, with care, brought to a true plane as to curvature and grade, and to a uniform thickness, the work is ready for the cushion for the brick, for which any good clean sand may be used whether it be sharp or spherical, but it is next to the impossible to spread it satisfactorily with a template or any other manner when it is wet, and if you insist on your pavement maintaining its symmetrical form the sand must be evenly spread; and there is but one method for doing this, and that is mechanically, by the aid of a template formed to fit the curvature of the street and armed with small metal wheels at either end, rolling on the curb at one end and on a $4'' \times 4''$ scantling laid lengthwise through the centre of the street at the other.

If the roadway of the street is not to exceed twenty-five (25) feet in width or less, the template can be made to span the entire width, both ends rolling on the curb.

This manner insures an even thickness of sand over the surface of the concrete, giving to each individual brick a like thickness of cushion, so that when the brick surface is rolled each brick will present the same resistance to the pressure of the roller, and you will then perforce have a smooth surface, otherwise if the sand is of uneven thickness the tendency of those brick resting over the thicker bed of sand is to sink under the pressure of the roller, lower than those resting over a thinner layer, and the result is an undulating and uneven surface.

Section 6. Brick.—The brick should all be hauled and neatly piled within the curb line before the grading is finished, or, if allowed by the engineer, delivered in wagons and carried from the pile or wagon on pallets with clamps—not wheeled with barrows. In hauling from car no throwing or dumping is allowed. They should be first class and thoroughly vitrified, showing at least one fairly straight face, if with rounded edges, with no greater radius than $\frac{3}{16}$ of an inch. They should not be less than $2\frac{1}{4} \times 4 \times 8$, or more than $3\frac{1}{2} \times 4 \times 9\frac{1}{2}$ inches, free from cracks, with but slight lamination, and at least one edge with but slight kiln marks allowed, and should stand the tests promulgated by the National Brick-makers' Association.

Extra Mention.—It is not only good practice to have all of the brick hauled and distributed just inside the curb line before the work of grading begins on any street block, but it is economy,

as experience has taught us that it is very expensive to attempt to get brick into a block after the other work has begun. Each side of the street should have the required number of brick neatly ricked up to lay to the centre of the street, thereby always maintaining the minimum distance to carry the brick to the setter.

In order to get the brick to the setter with the least possible abrasion or injury to the same, it is best to carry them on pallets, and so deposit them that the person laying them in the street will deposit them face edge up. No wheeling or teaming should be permitted over the brick at any stage prior to opening the same to the public.

SECTION 7. BRICKLAYING.—Brick may be laid either at a right angle or at an angle of 45 degrees to the curb as the engineer may direct, and in either way the line or course of brick must be kept straight or within a maximum variation of two inches; if greater than that, as many courses as necessary should be taken up and relaid until the defect in alignment is removed.

No parts of brick should be allowed in the pavement except the beginning or ending of courses or other closures. The brick must be laid with the best edges exposed as near in contact as possible; they must be closely inspected before laying and also after laying and after rolling. And all soft brick, or badly spalled or ill-shapen, must be removed and replaced with perfect ones. The kiln-marked ones may be turned over, and if the reverse edge is smooth and no other faults be found, it can remain in the pavement.

Extra Mention.—As to the alignment of the courses of the brick there is but little choice; either way is admissible without comment. The brick should be as nearly in contact as it is possible to lay them, for when the rolling is in progress, if there is appreciable space between the brick in the compression and bedding into the cushion sand, the brick will have a tendency to rock, and instead of receiving a flat foundation, as they should, it will be in a curved form, made by the rocking of the brick as the roller passes on and off of them, and the pavement will require more grout to fill the interstices.

It is not bad practice, if the gutter gradient is very flat, to lay five or six longitudinal courses parallel with the curb, as there will be less hindrance to the gutter drainage.

SECTION 8. ROLLING AND TAMPING.—After the brick in the pavement are inspected and the surface is swept clean of spalls, they must be well rolled with a five (5) ton steam-roller in the following manner: The brick next the curb should be tamped with a hand wood tamper to the proper gutter grade. The

rolling will then commence near the curb at a very slow pace and continue back and forth until the centre of the pavement is reached, then pass to the opposite curb and repeat in the same manner to the centre of the street. After this first passage of the roller the pace may be quickened and the rolling continued until each brick is firmly embedded in the sand cushion. The roller shall then be started at the end of the block and the pavement rolled transversely at an angle of 45 degrees to the end of the block, repeating the rolling in like manner in the opposite direction. Before this transverse rolling takes place all broken or injured brick must be taken up and replaced with perfect ones.

Extra Mention.—There is no question open to discussion as to the virtue of a steam-roller on a brick pavement. It is very necessary in order to give it a smooth surface. The transverse rolling is very necessary in order to remove the slight wavy condition of the surface, extending laterally from curb to curb, which will occur after the longitudinal rolling, and is the result of the thrust or impact occasioned by the propelling power of the roller. If the roller was drawn instead of being propelled these apparent waves would not occur. Therefore the transverse rolling will practically remove them. The longitudinal rolling should always be from curb toward the centre. The curved transverse section of the street has a tendency to move the brick endwise toward the curb, therefore, under the pressure of the roller, if you start the roller in the middle and roll toward the curb the gutter bricks that you have previously tamped to grade will be very much disturbed and your flow line will require retamping. If it were practicable to use the roller absolutely against the curb, the rolling might be done from the centre to the curb.

SECTION 9. EXPANSION CUSHION.—An expansion cushion must be provided for, one inch in thickness next to the curb, filled two-thirds of its depth with pitch, the top one-third being filled with sand.

Extra Mention.—This pitch joint next to and along the curb answers two purposes: it takes up the expansion of the brick and prevents a possible cracking of the pavement through and along the centre of the street, which sometimes occurs if the ends of the courses of the brick are abutted directly against the curb which acts as a skew-back or haunch to the arc of the pavement, which is often strong enough (especially if the sidewalk is up to and against the inside of the curb) to resist the force of expansion in that direction, and it will find relief in raising the pavement and the cracking mentioned above may

occur. And again, in taking up the expansion the brick are kept in contact with the sand cushion below, thereby preventing the rumbling noise so often heard, and occasioned wholly through lack of contact.

The inch of sand on the top of the pitch joint has a tendency to prevent the pitch from flowing, which it is likely to do in very hot weather. It is essential that the board occupying the place to be filled with pitch remain in place until after the street is in all other respects finished, but always withdrawn and the pitch applied within 36 hours after the application of the cement filler.

SECTION 10. THE FILLER.—The filler shall be composed of one part each of clean sand and Portland cement. The sand should be dry. The mixture, not exceeding one-third bushel of the sand, together with a like amount of cement, shall be placed in the box and mixed dry, until the mass assumes an even and unbroken shade. Then water shall be added, forming a liquid mixture of the consistency of thin cream.

From the time the water is applied until the last drop is removed and floated into the joints of the brick pavement, the same must be kept in constant motion.

The mixture shall be removed from the box to the street surface with a scoop shovel, all the while being stirred in the box as the same is being thus emptied. The box for this purpose shall be $3\frac{1}{2}$ to 4 feet long, 27 to 30 inches wide and 14 inches deep, resting on legs of different lengths, so that the mixture will readily flow to the lower corner of the box, which should be from 8 to 10 inches above the pavement. This mixture, from the moment it touches the brick, shall be thoroughly swept into the joints.

Two such boxes shall be provided in case the street is twenty feet or less in width; exceeding twenty feet in width, three boxes should be used.

The work of filling should thus be carried forward in line until an advance of fifteen to twenty yards has been made, when the same force and appliances shall be turned back and cover the same space in like manner, except to make the proportions two-thirds Portland cement and one-third sand.

To avoid the possibility of the thickening at any point, there should be a man with a sprinkling-can, the head perforated with small holes, sprinkling gently the surface ahead of the sweepers.

Within one-half to three-quarters of an hour after this last

coat is applied and the grout between the joints has fully subsided and the initial set is taking place, the whole surface must be slightly sprinkled and all surplus mixture left on the tops of the bricks swept into the joints, bringing them up flush and full.

After the joints are thus filled flush with the tops of the bricks and sufficient time for evaporation has taken place, so that the coating of sand will not absorb any moisture from the cement mixture, one-half inch of sand shall be spread over the whole surface, and in case the work is subjected to a hot summer sun, an occasional sprinkling, sufficient to dampen the sand, should be followed for two or three days.

Extra Mention.—Dry, sharp sand for this mixture is necessary without question or comment.

The first application should be thin in order that it may flow to the depth of the joints of the bricks, thereby insuring a substantial bond, and should be kept in constant motion while being applied, otherwise the sand will settle and you will have water and cement instead of water, sand, and cement. The water and cement would not be objectionable, but the sand by itself is wholly so.

It must also be mixed in small quantities, as it is next to impossible to keep the sand in suspension when more than a common water-pail of each, sand and cement, is used, and unless it is deposited upon the pavement with the sand in combination with the solution you will get the cement and water in the lower portions of the joints between the bricks and the sand without the cement in the upper portion. If you could get the sand in the lower and the cement in the upper portion of said joints, you would have a good grouted street. Some one, some day, may perfect a mechanical device for doing this satisfactorily, but at this time no such method is known. The rocking trough has been tried for the mixing and discharging, but invariably the cement and water will flow out first, then follows the sand to fill the upper parts of the joints; therefore the safest way is to use the scoop shovel a the specifications direct.

Ten days is the minimum time for keeping the street lockaded and free from traffic. Thirty days would be better, and longer if it were possible. In testin laboratories the usual time for allowing ceme ts (neat cements at that) to stand before applying the tests is twenty-seven days. Therefore when you open a grouted street to traffic in ten days you are demanding and expecting more from the cement than any testing laboratory would, so the street should remain closed as long as a suffering public will permit.

It is urgently insisted that in no case shall the proportion of cement be lessened.

Grouting thus finished must remain absolutely free from disturbance or traffic of any kind for a period of ten days at least.

Specifications for Paving, etc.—The following excerpts regarding brick street paving are taken from the Specifications of the Board of Local Improvements of Chicago, Ill.:

CEMENT.—In making the concrete, Portland cement shall pass same specifications as for cement used in curb and gutter work.

SAND.—The sand used in making the concrete shall be clean, dry, free from dust, loam, and dirt, of sizes ranging from one-eighth ($\frac{1}{8}''$) inch down to the finest, and in such proportion that the voids as determined by saturation shall not exceed thirty-three (33) per cent of the entire volume, and it shall weigh not less than one hundred (100) pounds per cubic foot.

No wind-drifted sand shall be used.

The sand when delivered on the street shall be deposited on flooring and kept clean until used.

CRUSHED STONE.—The crushed stone used in making the concrete shall be of the best quality of limestone, clean, free from dirt, broken so as to measure not more than two ($2''$) inches and not less than one ($1''$) inch in any dimension.

The stone when delivered on the street shall be deposited on flooring and kept clean until used.

MIXING AND LAYING OF CONCRETE.—The concrete shall be mixed on movable tight iron platforms of such size as shall accommodate the manipulations hereinafter specified.

The cement, sand, and stone shall be mixed in the following proportions: One (1) part of cement, three (3) parts of sand, and seven (7) parts of crushed stone. The sand and cement shall be thoroughly mixed, dry, to which sufficient water shall be added and then made into a stiff mortar. The crushed stone shall then be immediately incorporated in the mortar and the mass thoroughly mixed, adding water from time to time as the mixing progresses, until each particle of stone is covered with mortar.

The concrete shall be removed from the platform with shovels and deposited in a layer on the roadway in such quantities that after being rammed in place it shall be of the required thickness

and the upper surface shall be true and smooth and......(..″) inches below and parallel with the top of the finished pavement.

During the progress of the *work the sub-grade must be kept moist.*

The concrete shall be sprinkled so as to prevent checking in hot weather, and shall be protected from injury at all times, and shall lay at least seven days before being covered with the wearing surface, or a longer time if deemed necessary.

SAND CUSHION.—Upon the concrete foundation shall be spread a layer of sand in such quantity as to insure, when compacted, a uniform thickness of one (1″) inch.

On surfacing said layer of sand the contractor or contractors shall use such guides and templets as the engineer may direct.

WEARING SURFACE.—Upon the layer of sand as above specified shall be placed the brick of such quality and in such manner as hereinafter specified.

QUALITY OF BRICKS.—The brick to be used shall be of the best quality of vitrified paving brick. Salt-glazed bricks will not be received.

The dimensions of the brick used shall be the same throughout the entire work in any particular case, and shall be not less than eight (8″) inches in length, four (4″) inches in depth, and two and one-half (2½″) inches in thickness, with rounded edges to a radius of one-quarter (¼″) of an inch.

Said brick shall be of a kind known as repressed vitrified paving brick and shall be repressed to the extent that the maximum amount of material is forced into them. They shall be free from lime and other impurities, shall be as nearly uniform in every respect as possible, shall be burned so as to secure the maximum hardness, so annealed as to reach the ultimate degree of toughness, and thoroughly vitrified so as to make a homogeneous mass.

The bricks shall be free from all laminations caused by the process of manufacture, and free from fire-cracks or checks of more than superficial character or extent.

Any firm, person, or corporation bidding for the work to be done shall furnish specimen brick, which shall be submitted to a "water-absorption" test, and if such brick show a water absorption exceeding three (3) per cent of their weight when dry, the bid of the person, firm, or corporation so furnishing the same shall be rejected. Such "water-absorption" test shall be made by the Board of Local Improvements of the City of

Chicago, in the following manner, to wit: Not less than three (3) bricks shall be broken across, thoroughly dried, and then immersed in water for seventy-two (72) hours. The absorption shall then be determined by the difference between the weight dry and the weight at the expiration of said seventy-two (72) hours.

Twenty or more specimen bricks shall also be furnished by each bidder for submission to the "abrasion" test by the Board of Local Improvements. Such test shall be made in the following manner, to wit: Such specimen brick or a sufficient number to fill 15 per cent of the volume of the rattler shall be submitted to a test for one hour in the machine known as the "rattler," which shall measure twenty (20'') inches in length and twenty-eight (28'') inches in diameter, inside measurement, and shall be revolved at the rate of thirty (30) revolutions per minute If the loss of weight by abrasion during such test shall exceed twenty (20) per cent of the original weight of the brick tested, then such bid shall be rejected.

All brick shall have a specific gravity of not less than two and one-tenth $(2^1/_{10})$, as determined by the formula specific gravity equals $\dfrac{W}{W'W''}$; where W equals weight of brick dry, W' equals weight of brick after being immersed in water for seventy-two (72) hours, and W'' equals weight of brick in water.

All brick used must be equal in every respect to the specimen submitted by the bidders to the Board of Local Improvements for test.

How Laid.—All brick shall be delivered on the work in barrows, and in no case will teams be allowed on the street before the wearing surface is rolled.

Broken bricks can only be used to break joints in starting courses and in making closures, but in no case shall less than half a brick be used.

The bricks shall be laid on edge, close together, in straight lines across the roadway, between gutters, and at right angles to the curbs and perpendicular to the grade of the street. Gutters shall be constructed as directed by the engineer.

The joints shall be broken by a lap of not less than three (3'') inches.

On intersections and junctions of lateral streets the bricks shall be laid at an angle of forty-five (45°) degrees with the line of the street unless otherwise ordered by the engineer.

The bricks when set shall be rolled with a roller weighing not less than five (5) tons until the bricks are well settled and made firm. Or, if the engineer shall direct, the bricks, when set, shall be thoroughly rammed two or more times, the ramming to be done under a flatter, with a paving rammer weighing not less than thirty (30) pounds, the iron of the rammer face in no case to come in contact with the pavement.

After rolling and ramming, all broken brick found in the pavement must at once be removed and replaced by sound and perfect brick.

PITCHING OR GROUTING AND TOP-DRESSING. — When the bricks are thoroughly bedded, the surface of the pavement must be true for grade and crown. The surface of the pavement shall then be swept clean, and the joints or spaces between the brick shall be completely filled with a paving pitch which is the direct result of the distillation of "straight-run" coaltar, and of such quality and consistency as shall be approved by the Board of Local Improvements. The pitch must be used at a temperature of not less than 280 degrees Fahrenheit.

When the brick are thoroughly bedded, the surface of the pavement must be true for grade and crown. The surface of the pavement shall then be swept clean, and the joints or spaces between the bricks shall be filled with a cement grout filler composed of limestone 65 per cent, furnace slag 25 per cent, and potters' clay 10 per cent, to be made as follows: The above materials in the proportions stated shall be mixed together and ground into an impalpable powder and then burned in kilns until reduced to clinker, after which it shall again be ground into an impalpable powder. Equal portions of said grout and clean, sharp sand shall then be thoroughly mixed, and sufficient water added to bring the mixture to such a consistency as will allow it to run to the bottom of the joints between the brick. After said joints are filled to the top, the surface shall be finished off smoothly with steel brooms.

After the spaces between the brick have been filled with the pitch or grout as above specified, the surface of the pavement shall then receive a one-half ($\frac{1}{2}''$) inch dressing of sand, evenly spread over the whole surface.

Where cement grout is used as a filler the pavement must be kept clear of traffic for a period of four (4) days—or as much longer as the engineer may direct—after the application thereof.

ASPHALTIC CEMENT.—The asphaltic cement hereinafter speci-

PART III.

LAYING OUT WORK. BOND, ETC., IN ARCHES. SHORT CUTS AND METHODS OF DOING WORK. ORNAMENTAL WORK WITH PLAIN BRICK. TOOLS, ETC., USED.

Up to within the past few years the foreman or superintendent on any work of construction was usually a carpenter, and was expected to do all the laying out, giving lines, angles, etc., in the various branches of the work, including the stone and brick masonry. Of late years, however, the types of buildings have so changed that the several branches of masonry now constitute the larger part of construction, and it is not uncommon for the foreman or superintendent of a building to be a stone or brick mason capable of doing all the laying out, etc., formerly done by the carpenter. Hence in preparing a book for the use of stone or brick masons the author has deemed it wise to devote several pages to laying out work, as follows.

Laying Out Work.

To Lay Out Arches.—LANCET GOTHIC ARCH.—A lancet Gothic arch is one whose radius is greater than its width, as shown in Fig. 105.
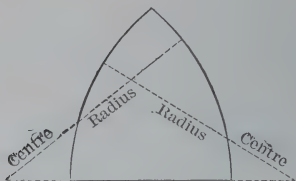
FIG. 105.—Lancet Gothic Arch.

TO DRAW THE GOTHIC ELLIPTICAL ARCH.—Divide the span *ab* into three equal parts at *c* and *d*, Fig. 106; with *bc* as radius
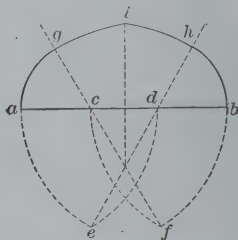
FIG. 106.—Gothic Elliptical Arch.

and *a, c, d, b* as centres, draw the arcs, as shown, finding points *e* and *f*; now, from *e* and *f* draw lines through *c* and *d*, as shown; with *c* and *d* as centres and *ac* as radius draw arcs *ag* and *hb*,
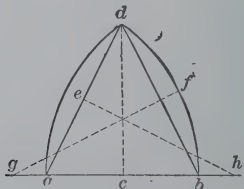
FIG. 107.—Lancet Gothic Arch.

and with *e* and *f* as centres and *eh* as radius draw arcs *gi* and *ih*, completing the curve of the arch.

To Draw the Lancet Gothic Arch when the Span and Rise are Given.—On the base line, Fig. 107, mark the span *ab* and from the centre draw the rise *cd*; now connect *ad* and *db*, and from the centre of these lines draw a line at right angles to strike the base line, as *gf* and *eh*; now *g* is the centre and *gb* the radius to draw the arc *db*, and *h* the centre and same radius to draw the arc *ad*.

Gothic Arch.—The most common Gothic arch is one whose radius is equal to its width, as shown in Fig. 108.

Fig. 108.—Gothic Arch.

All Gothic arches are easily struck from the centre, usually shown on the drawings.

To Draw a Flat-pointed Arch to a Given Width and Rise. —Draw the width, as *AB*, Fig. 109, and the height, as *OC*, while *CD* is a line tangent to the upper ci cle; now draw *C3* at right angles to *DC*, and from *A* draw the perpendicular *AD*; now find point *I*,

Fig. 109.—Flat-pointed Arch.

making *AI* equal to *AD*; now find point *E*, making *CE* equal to *AD*, and connect *I* and *E*; now bisect the line *EI*, as shown,

and draw a line to meet $C3$; now from 3 draw a line through point I as $3D$, and I and 3 will be the centres to strike the arch; then transfer the points across to 2 and 4 for the centres for the other half.

DROP ARCH.—A drop arch is one whose radius is less than its width, as shown in Fig. 110.

Another form of drop arch is shown in Fig. 111.
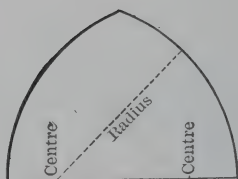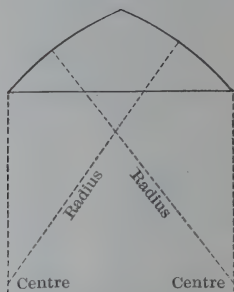
FIG. 110.—Drop Arch.   FIG. 111.—Drop Arch.

THREE-CENTRE ARCH.—With ab as width of arch and e as centre, Fig. 112, take ea as radius and strike semicircle ab; then, with a as centre and ab as radius, strike arc bc; then,
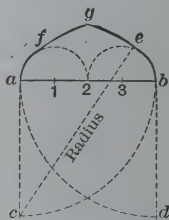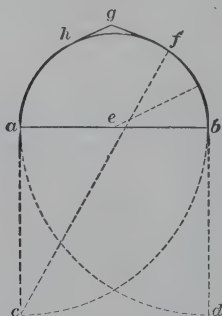
FIG. 112.—Three-centre Arch.   FIG. 113.—Four-centre Arch.

with b as centre and same radius, strike arc ad; then, with c as centre and cf as radius, strike arc gf; then, with d as centre and same radius, strike arc gh, thus completing the arch.

FOUR-CENTRE ARCH.—To strike a four-centre arch divide the width into four equal spaces, as 1, 2, 3, Fig. 113; then, with 1 as centre and 1a as radius, strike semicircle a2; then, with 3 as centre and same radius, strike semicircle 2b; then, with ab as radius and a as centre, strike arc bc; then, with same radius and b as centre, strike arc ad; then, with c as centre and ce as radius, strike arc ge; then, with same radius and d as centre, strike arc fg, completing the arch.

TO DRAW THE TUDOR OR GOTHIC ARCH.—Let ab be the span and cd the rise, Fig. 114; with ab as radius and c as centre
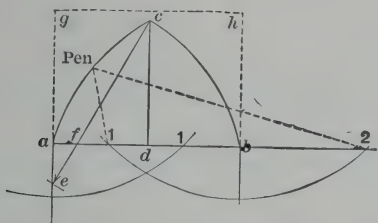
FIG. 114.—Tudor Arch.

draw an arc through the perpendicular at e, connect c and e, make ag and bh equal to cf; now, with ab as radius and g and h as centres, find points 1 1 and 2 2 on the base line; drive a nail in each of these points to attach a string; fasten the string at 2 and carry it around the pencil at c and make fast at point 1 on the opposite side; now draw the pencil from c to a, keeping the string tight, and it will describe the arch; then reverse the string for other side.

AT POINT c ON THE LINE ab TO DRAW TWO ARCS OF CIRCLES TANGENT TO ab AND THE TWO PARALLELS ah AND be FORMING AN ARCH.—Make ad, Fig. 115, equal to ac and be equal to bc; draw cf at right angles to ab and dg at right angles to ah; with g as centre and radius gd draw the arc dc; draw ef at right angles to be; with f a centre and fc as radius draw the arc ce, completing the arch.

TO SPACE THE KERFING OF MOULDINGS, ETC.—Strike a circle of the same dimensions as that which it is desired to spring the moulding around; take a piece of the moulding and make a kerf in it and place the moulding across the circle as shown by Fig. 116, with the kerf at the centre; now hold that part

of the moulding marked A solid and bend the part marked B until the kerf or saw cut comes together. The distance the piece
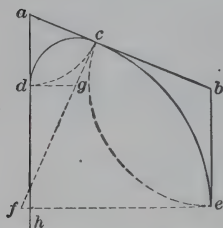
Fig. 115.—Arch of Two Arcs of Circles.
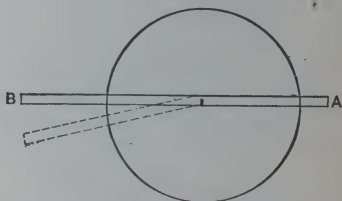
Fig. 116.—Kerfing of Moulding.

of moulding B has moved on the circle will be the distance apart to space the kerfs.

To Lay Out an Arch or Curve Similar to an Ellipse, but whose Axes do not Stand at Right Angles.—Draw a parallelogram whose sides equal the axis, as A, B, C, and D, Fig. 117; now draw the two centre lines EF and GH;
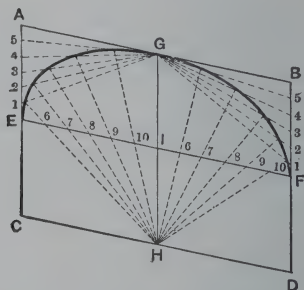
Fig. 117.—Deformed Ellipse.

divide AE and BF into any number of equal parts, as 1, 2, 3, etc.; then divide E1 and 1F into the same number of parts and draw lines radiating from G to points 1, 2, 3, etc.; then draw lines radiating from H through points 6, 7, 8, etc., to strike the lines radiating from G, and through these intersections draw the curve as shown.

When any Three Points are Given, to Draw a Circle whose Circumference shall Strike Each of the Three Points.—With a, b, and c as the points, Fig. 118, join a and b

and *a* and *c* together, and draw lines at right angles from the centre of *ab* and *ac*, bisecting at *d*, which is the centre of the circle, and *da* the radius.
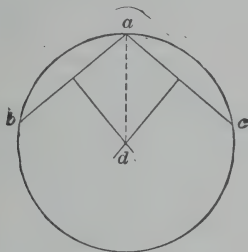
FIG. 118.—To Draw Circle through Three Points.

To Find the Centre of a Circle.—Take any three points on the circumference and join them, as *a*, *b*, *c*, Fig. 119; then
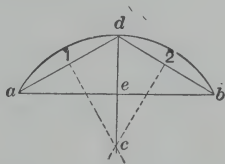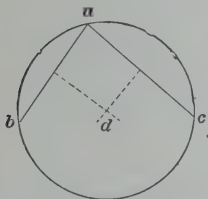
FIG. 119.—Finding Centre of Circle.   FIG. 120.—Diameter of Arc.

draw lines at right angles from the centre of *ab* and *ac* and the bisecting point *d* is the centre.

To Find the Diameter or Radius of a Circle when the Chord and Rise of an Arc are Given.—Draw the chord as
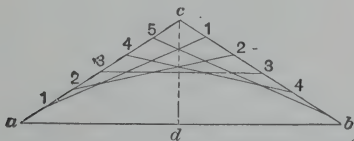
FIG. 121.—To Draw an Arc.

ab, then the rise *de*, Fig. 120; then connect *ad* and *db*; then draw lines 1*c* and 2*c* at right angles, and from the centre of

ad and db, until they intersect at c, which is the centre and cd the radius.

To Draw an Arc by Intersecting Lines when the Chord and Rise are Given.—Draw the chord as ab, Fig. 121; then draw cd equal to twice the rise, divide ac and cb into the same number of equal spaces and draw the lines as shown.

Fig. 122.—To Draw an Arc.

To Draw an Arc by Bending a Lath or Strip.—Let ab be the span and cd the rise, Fig. 122, with cd as radius and d as centre, draw the quarter-circle ce; now divide ce and ed into the same number of equal parts, as 1, 2, 3, etc.; now divide db and da into as many equal parts as de; now connect 1, 2, 3 on the quarter-circle and 1, 2, 3 on de, as shown; now draw lines from the points on ad and db, at the same angle and equal in length to the ones on the quarter-circle, as 1 1, 2 2, etc.; drive nails in these points and bend the strips around.

When the Span and Rise of an Arc are Given, to Draw the Curve.—Draw the span ab and rise c, Fig. 123; then, with
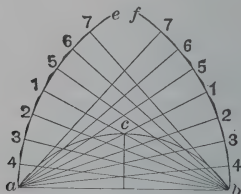
Fig. 123.—To Draw Curve of Arc.

a and b as centres and ab as radius, draw arcs ae and bf; now draw lines from a and b through c until they strike ae and bf, as $a1$ and $b1$; divide $a1$ on ae and $b1$ on bf into any number of equal spaces, as 1, 2, 3, etc.; make 5, 6, 7 equally distant

and draw the lines as shown; draw the curve through the intersections as shown.

WHEN THE CHORD AND RISE OF AN ARC ARE GIVEN, TO DRAW THE ARC.—Take two strips and joint the edges
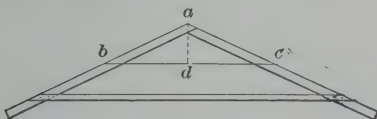
FIG. 124.—Frame to Strike Arc.

straight and make a frame, as shown in Fig. 124; bc is the chord and ad the rise of the arc. Drive a nail in the floor or drawing-board on the outside edge of the frame at b and
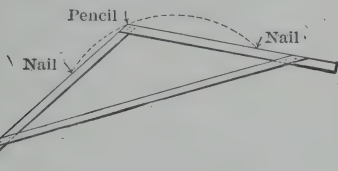
FIG. 125.—Use of Frame.

another one at c; then place the pencil at the point of the frame, a, and slide the frame around, keeping it tight against the nails, when the pencil will describe the curve, as shown in Fig. 125.

WHEN THE CHORD AND RISE OF AN ARC ARE GIVEN, TO FIND THE RADIUS.—Square one half the chord, divide this product by the rise and to this answer add the rise and divide by 2; the answer is the radius. In Fig. 126, one half the chord is 4, which squared equals 16, which divided by the rise equals $5\frac{1}{3}$, to which add the rise, equals $8\frac{1}{3}$, which divided by 2 equals $4\frac{1}{6}$, the radius.
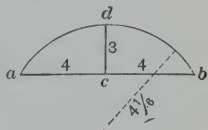
FIG. 126.

LAYING OUT MANSARD AND GAMBREL ROOFS.—To proportion a mansard or gambrel roof, draw a half-circle to a scale, using the width of the building as the diameter, then draw the two slopes of the roof so that they intersect on the circle, as shown by Fig. 127.

LAYING OUT CIRCLE HEADS IN CIRCLE WALLS.—This can be done with lines and circles, but the quickest way for the work-

FIG. 127.—Mansard or Gambrel Roof.
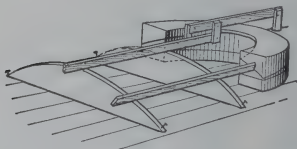
FIG. 128.—Working Circle on Circle-heads.

man is to cut out the head-piece to the desired circle for the frame; then make two templates equal to the circle of the wall and tack them on the drawing-board or floor, as shown by Fig. 128; now with a couple of straight-edges and pencil mark out the circle of the wall by sliding the strips over the templates.

TO LAY OUT ENTASIS OF COLUMNS, ETC.—Draw length of column, as AB, Fig. 129, then AC, the radius of the column at the bottom, and DB, the radius of the column at the top; now describe the quarter-circle CE, and let fall the perpendicular DF. Divide the length of the column into spaces equal to the bottom radius, spacing from E, as G, H, I and J; divide the arc CF into the same number of equal spaces; now draw lines from the points on the centre line and at right angles to it, as $E6$, $G7$, etc., and draw perpendicular lines from points 1, 2, etc., on the arc to strike the lines from the centre line, as shown at 6, 7, 8, etc., and through these points draw the curve. Fig. 129 is drawn with considerable swell, so that the lines can be seen more plainly.

FIG. 129.— Entasis of Columns.

To Draw a Regular Polygon of any Number of Sides
when the Length of One Side is Given.—Take the length of
the side for a base, as *ab*, Fig. 130;
then with *ab* as radius and *a* as
centre draw the semicircle, *db*;
then divide the semicircle into as
many equal parts as there are
sides to the polygon, in this case
7; then, as we have one side, *ab*,
we skip the first division and
connect *a* and 2; then from the
centre of *a*2 and *ab* draw lines at
right angles until they meet at *c*,
which is the centre of the poly-
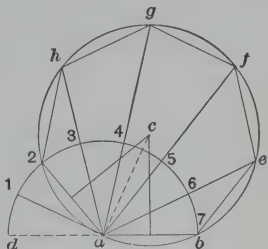
Fig. 130.—To Draw Polygons.

gon. Then, with *c* as centre and *ca* as radius, draw the circle;
then draw lines from *a* through points 3, 4, 5, and 6, striking
the circle at *h, g, f,* and *e*; now connect 2*h, hg, gf, fe,* and *eb*.

When the Two Axes are Given, to Draw a Curve Ap-
proximating an Ellipse.—With *cd* as the major axis and
ag the minor axis, Fig. 131, draw lines connecting *ad* and *ac*;
then, with *b* as centre and *ba* as radius, draw the semicircle,
finding points *e* and *f*, from which points draw lines at right
angles to *ad* and *ac*, intersecting at *g*; then, with *ga* as radius
and *g* as centre, strike arc 1 2; then, with *i* as centre and *i*2
as radius, strike arc 2*d* and repeat same for other side.
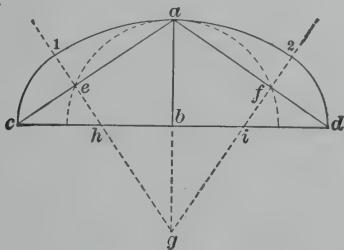
Fig. 131.—Curve Approximating an Ellipse.

To Draw an Ellipse with a String.—Draw the long diam-
eter, Fig. 132, as *ab*; then half the short diameter, as *cd*; then,
with *c* as centre and *ad* as radius, describe arcs bisecting *ab*
at 1 and 2, at which points drive a nail to fasten the string;

then fasten the string at 1 and stretch to c, at which point place a pencil inside the string and carry the string to 2 and make fast; then keep the string tight and run the pencil along on the inside of the string and the mark will be the ellipse; 3 and 4 show position of pencil and string on the curve.
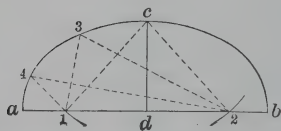
FIG. 132.—Drawing Ellipse with String.
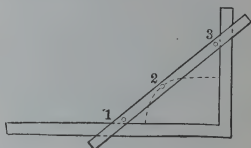
FIG. 133.—Drawing Ellipse with Square.

TO DRAW AN ELLIPSE WITH THE SQUARE.—Take a strip of wood, as shown in Fig. 133, say $\frac{1}{2}'' \times 1''$, to use as a rule; then drive a nail through the stick about an inch from one end, as 1; then make the distance between 1 2 equal one-half the short
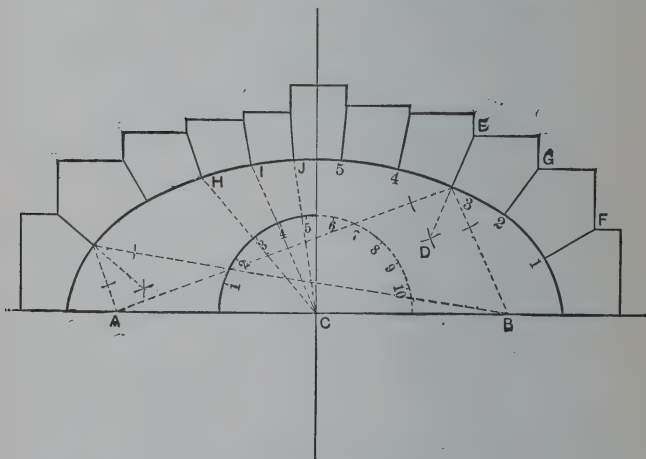
FIG. 134.—Voussoirs of an Elliptical Arch.

diameter of the ellipse and 2 3 equal to one-half the long diameter; drive another nail at 3, and at 2 make a hole for a pencil, place the pencil in the hole and slide the stick from a perpen-

dicular position to a horizontal one, keeping the nails against the inside of the square, and the pencil will describe an ellipse.

To Lay Out the Voussoirs of an Elliptical Arch.—There are two methods of laying out the voussoirs of an elliptical arch, as shown by Fig. 134. In method A the voussoirs decrease in size towards the top of the arch, while in method B they are all about the same size.

To locate the joints in method A, use C as centre and strike a half-circle as shown, and divide the half-circle into as many equal spaces as there are desired voussoirs in the arch, always making the number odd so as to include the keystone. The divisions in this case being indicated by 1, 2, 3, etc., draw lines from C radiating through these points to strike the curve of the ellipse, as H, I, J, etc. This is the location of each joint.

In method B the curve of the ellipse is divided into as many equal spaces as there are desired voussoirs, counting the key as one.

To lay out the joints in either method connect the point of the joint on the curve with the two foci A and B, which are found as shown by Fig. 132; bisect the angle formed by these two lines, as shown by the line D–E, which gives the joint. Repeat the operation for each joint. The length of all joints should be the same, as I–F, 2–G, etc.
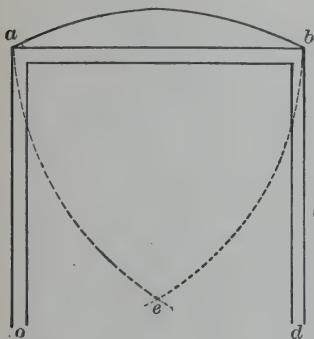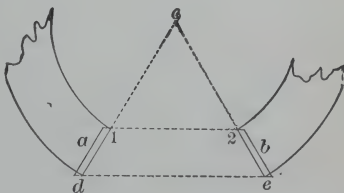
FIG. 153.—Arch Lintel.   FIG. 136.—Splayed Jambs.

To Lay Out an Arch Lintel.—The rule is to use the width of the frame as radius. Example: abcd, Fig. 135, represent the frame; now, with a as centre and ab as radius, draw the

arc *be*; with *b* as centre and same radius draw arc *ae*, and with the intersection *e* as centre and same radius draw the desired arc *ab*.

To Find the Pattern of Veneers for Circle-splayed Window- or Door-jambs.—Draw a section of the frame. as *a* and *b*, Fig. 136; then continue the lines 1*d* a d 2*e* until they meet at *c, ce* or *cd* is the radius to lay out the veneer.

Joints of a Gothic Arch.—The usual method of building a Gothic arch is shown by Fig. 137, the joints all radiating from the centres 1 and 2 used for striking the arch. This method requires the brick to be clipped at the top of the arch, as shown at *A*. If there is no weight on the top of an arch built in this way and there is much pressure on the sides there is a tendency to shove out the wedge-shaped bricks at the top and cause the arch to collapse.
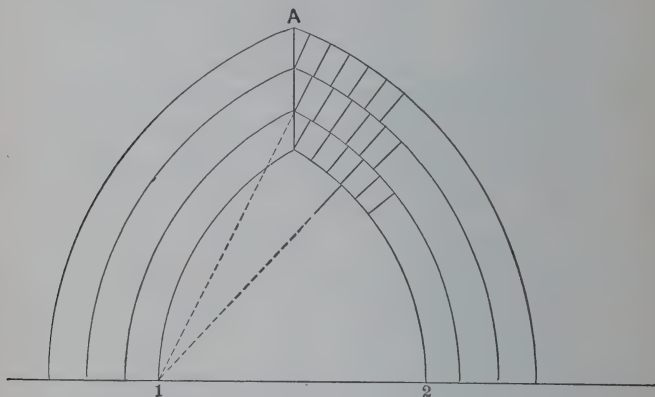
Fig. 137.—Joints in Gothic Arch.

A method to overcome this fault is shown by Fig. 138. The arch is built in the usual manner, using the centres *A* and *B* for the radii of the joints until the arch has been completed about three-fourths of the springing distance, or to *A–C* and *B–D*. Now take the intersection of *A–C* and *B–D*, as *I* for centre, and radiate the joints for the balance of the arch from this point as shown. An arch built in this way will usually require special-shaped brick for the top part.

Dutch or French Arch.—Fig. 139 shows what is called a Dutch or French arch. It is built by clipping the brick as

shown. It is very weak and not much used in modern con·
struction.
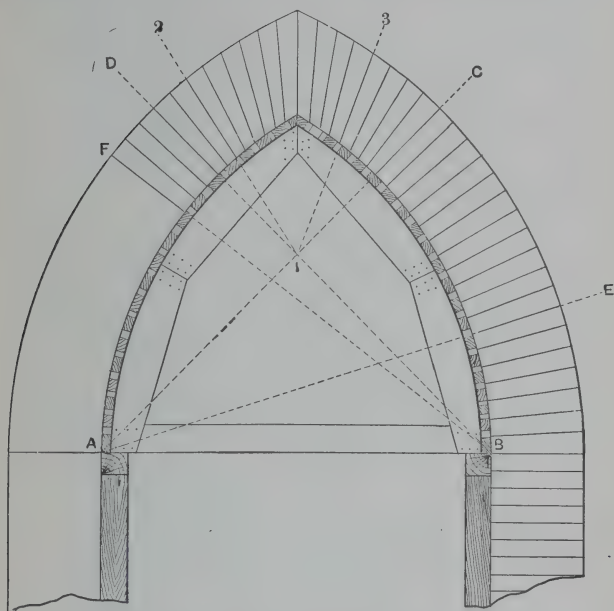
Fig. 138.—Laying out Joints of Gothic Arch.

SECRET ARCH LINTEL.—Fig. 140 shows how a secret arch is
sometimes cut in stone when it is desired to form a lintel and
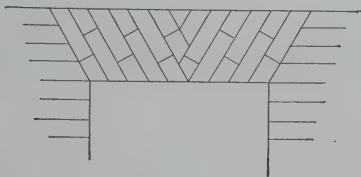
Fig. 139.—Dutch or French Arch.

keep the joints showing plumb. The stones are cut with the
face joint plumb and the interior part of the stone cut to form
the arch as shown.

Fig. 141 shows methods of carrying stone lintels over openings. The lintels are made in parts and cramped onto the I beam as shown.
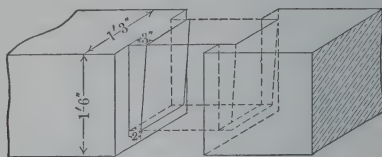
FIG. 140.—Secret Arch.

To Hang Projecting Stone Courses.—Fig. 142 illustrates a method the author has used for hanging heavy projecting courses of stone between piers or columns with bolts and beams.

In the top of the stone where it is desired to put the bolt for hanging drill a hole down in the stone large enough to insert
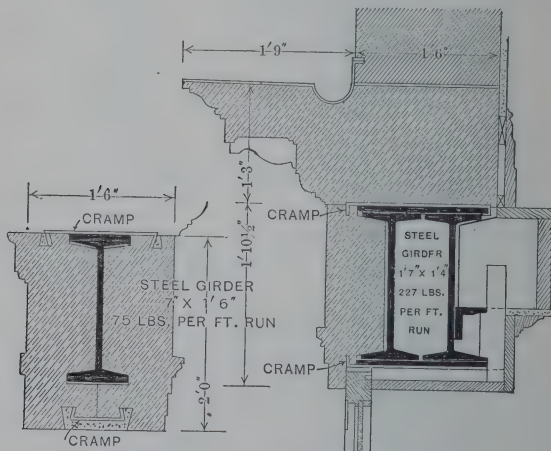
FIG. 141.—Beam-supported Stonework.

an eye-bolt, as shown; drill this hole to the required depth and then in the end of the stone, as at A, drill another hole to intersect the first one drilled and permit of a pin being run through the eye-bolt. This method is stronger and more

quickly done than with expanded bolts. After the stones are in place and the weight on the bolts fill the holes solid with neat cement mortar.

CENTRES FOR BRICK OR STONE WORK.— All arches built either of brick or stone should be turned on a wood centre
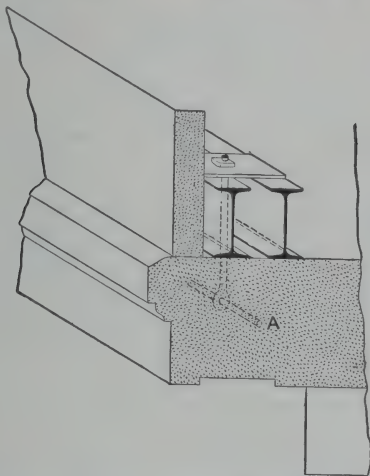
FIG. 142.—Stone Courses Hung from Beams.

made to the exact shape of the arch. It should be made strong enough to carry whatever weight will be put on it without sagging. For arches over 5 feet the centres should be built of 2-inch plank and braced so that they will be rigid and solid.

The centre should be set back a little from the face line of the wall, so that it will be out of the way of the mason's line.

For stone arches it is advisable to make the centre about $\frac{1}{4}$ inch smaller than the exact size of the arch and set the arch stones on small wedges; the stone can then be adjusted a little if necessary. For brick arches the centre must, of course, be made the exact size. Fig. 143 shows a good method of building a centre for large arches. It should be made of 2-inch plank and 4-inch timber used for the frame. It is advisable to set the centre on wedge-shaped blocks as shown at D, as the centre can then be loosened by driving out one of the wedges.

SPACING OF ARCH, BRICK OR STONE.—Before starting an arch
of either brick or stone, the joints of the arch should all be
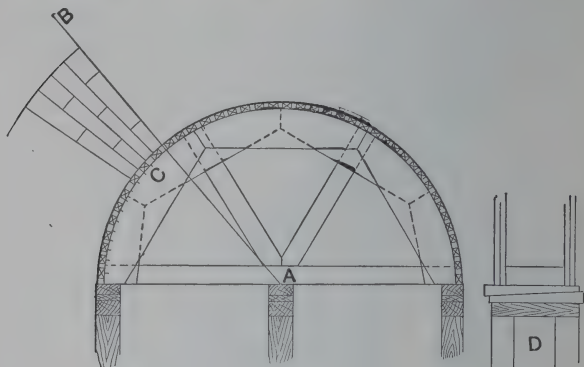
FIG. 143.—Spacing Joints of Arch.

spaced out with a pair of dividers and marked on the centre
as shown at C, Fig. 143. A short piece of line should then
be fastened at the centre, as at A, and each course of brick
or stone in the arch should be set to this line, which should be
stretched taut and held to the joint mark on the centre.
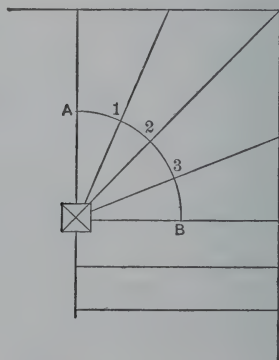
FIG. 144.—Winding Stairs.

By spacing the joints out in this manner there will be no
trouble in putting in the last course or key.

To Lay Out Winding Stair-treads.—Make a drawing of the space to be taken up with the winders and draw an arc as AB, Fig. 144; divide this arc into as many equal spaces as steps desired, as 1 2 3; draw lines adiating from the centre of the newel through these points, which give the size and shape of the different steps.
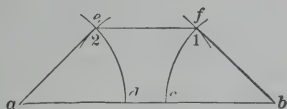
Fig 145.—Octagon Bay.

To Lay Off an Octagon Bay when the Length of One Side is Given.—First draw a line to represent the side of the house, as ab, Fig. 145; then with the trammel set the length of the side, place the foot at a and find point d; make the distance from d to c five-twelfths of ad; then, with the foot of the compasses at c, find point b; with the foot at b, strike the arc f; with the foot at d, find point 1; with the foot at a, strike the arc de; with the foot at c, find point 2; then connect ae, ef, and fb.

To Lay Out a Hexagon Bay Window when the Length of One Side is Given.—Draw the line ac as side of the house, Fig. 146; then, with a as centre and the given side as radius, strike arc db; then, with b as centre, find point c; then, with
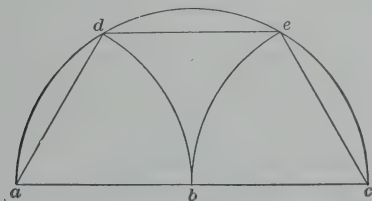
Fig. 146.—Hexagon Bay

c as centre, strike arc eb; now with b as centre, strike semi-circle $adec$; now connect ad, de, and ec.

To find the side of an octagon bay when the length on the house is given: Divide the distance on the house by $2\frac{5}{12}$, and the answer will be the length of the side.

To find the distance on the house when the side is given: Multiply the side by $2\frac{5}{12}$, and the answer will be the diameter of the octagon.

SHORT CUTS, ETC.*

To Sling a Column.— Take two ordinary slings of equal length, weave them together, as shown by Fig. 147, and place them over the top of the column as shown by Fig. 148.

To Sling a Pole or Timber on End.—Fig. 149 shows how to hitch to a pole or timber to be hoisted on end; a hitch of this kind will not slip.

FIG. 147.

To Sling a Barrel.—Fig. 150, cuts 1, 2, 3, shows how to sling a barrel for hoisting mortar, etc., using an ordinary sling.

ANOTHER METHOD TO SLING A BARREL OR CAN.—Fig. 151 shows a ready way of slinging a can, to improvise a paint-pot, to dip for water, etc. Pass the end of the cord under the bottom of the can and bring the two parts over it, and make with them an overhand knot; open the knot, as shown in Fig. 152, and draw the two parts down until they come round the upper edge of the can; haul taut and knot them together again over the can, as shown in Fig. 151.

FIG. 148.

To Sling a Plank Edgewise.— The method of slinging a plank edgewise by a rope so that it will stay is shown in Fig. 153. A clove-hitch is made around the end of the plank, then one of the parts is twisted around the plank until the ends lead as shown.

To Shorten a Rope without Cutting.—To shorten a piece of rope without cutting it try the sheep-shank shown in Fig 154. The rope is brought back on itself, making two or

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* Several cuts in this part have been used by permission of the editor of *Practical Carpenter*.

more bights, and a half-hitch is taken around each bight.
This knot will not slip, and will nearly fall apart of its own
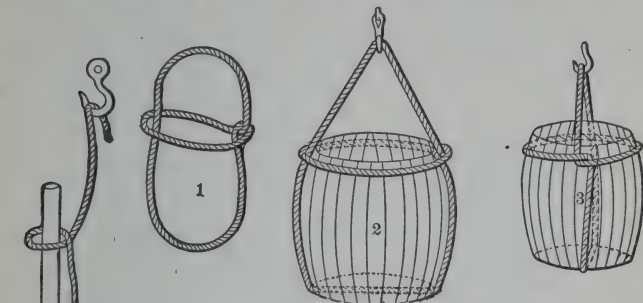
FIG. 150.—To Sling a Barrel.
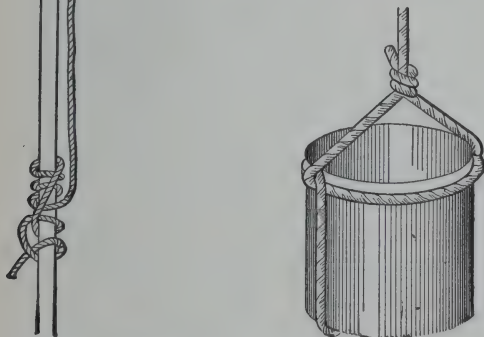
FIG. 149.—To Sling a Pole.   FIG. 151.—To Sling a Can.
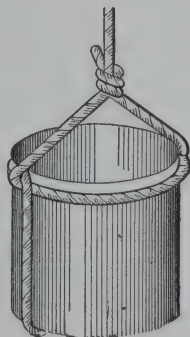
accord if the strain is released, so that when there is a liability
of this happening it is well to pass a piece of wood through
the loop A at each end and pull the rope tight on them.
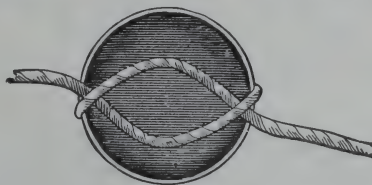
FIG. 152.—Slinging Can.

How to Tie a Jury-mast Knot.—This knot is also
known as a masthead knot and a bottle-hitch, and is used at

the top of a temporary derrick in place of a mast iron to fasten the guys to.

Take a piece of stout cord and hold it between the thumb and forefinger of each hand, with a space of about 6 inches between the hands. Then twist the cord right-handed with the thumb and forefinger of the right hand only. This will throw up a bight like Fig. 155, with the part A under B. Grasp the loop thus formed between the thumb and forefinger of the left hand at the point where the two parts cross. Then move the thumb and forefinger of the right hand
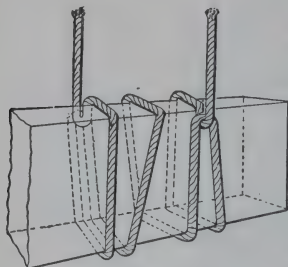
FIG. 153.—Slinging Plank.

along the cord about 6 inches, and throw up another bight, laying it on top of the first one. You then have Fig. 156. Hold these two bights with the left thumb and forefinger, measure off another 6 inches, and throw the last bight. **Place it on top**
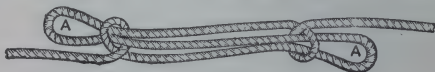
FIG. 154.—Sheep-shank.

of the last one made and you have Fig. 157. Take the part E in the last bight at Fig. 157, and, while holding the other parts in place, pass it under B, over C, and under A. This makes Fig. 158. Then take B, Fig. 158, and pass it under D and over F.
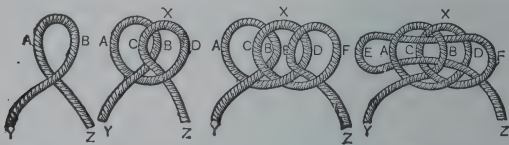
FIG. 155. FIG. 156. FIG. 157. FIG. 158.
Jury-mast Knot.

The result is Fig. 159. Then, while holding E in the left and B in the right hand, take hold of X with the teeth and pull it. The result will be Fig. 160. In practice, the part O in Fig. 160 goes over the reduced part of the mast- or derrick-head. The forestay is made fast to X; the stays to B and B; Y and Z form the backstays. Any strain on the stays tightens up O.

By pulling Y and Z in opposite directions the knot comes out. Every workman should know how to tie this knot.

Stop-knot.—Fig. 161 shows how to fasten a line to another on which there is a strain, such as a guy-line, etc.; this is often necessary when it is desired to tighten a guy-line. Take a smaller
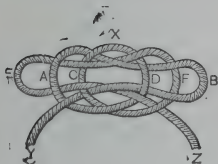
FIG. 159.—Jury-mast Knot.   FIG. 160.
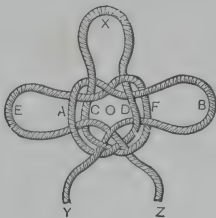
size rope, as A, and with the left hand hold it against the larger rope, and make three round turns toward the right of the larger rope. Bring the end of the smaller rope marked B back, and take three half-hitches to the left. Bring the end of the small rope marked A through the loop at C, and attach set of blocks to take the strain.

Another method of taking hold of a rope with a strain on it is shown by Fig. 162. Take a sling made of a smaller rope and
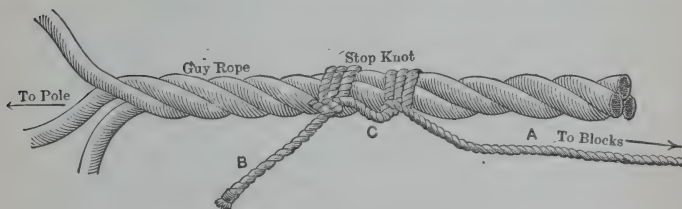
FIG. 161.—Stop Knot.

wrap it around by alternate cross-turns and attach blocks as shown.

To Sling a Plank by Staging.—Make a marlinespike hitch as shown by Fig. 163. Place the end of the plank in the bight occupied by the marlinespike; draw it taut, as shown by Fig. 164, with the double part of the bight on the under side of the plank.

Fastening for Ledger-boards.—Fig. 165 shows a method of fastening ledger-boards to posts or uprights by means of a wrought-iron clamp or stirrup. Two holes are bored through the upright, the stirrup inserted, and the ledger-board bolted fast as shown. *B* is the putlog laid in place. This method is quicker and stronger than nails, and does not destroy any lumber.
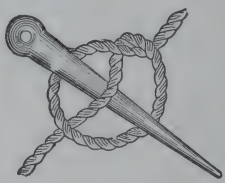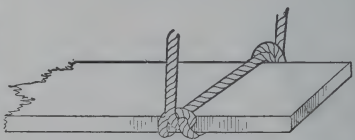
FIG. 162.   FIG. 164.—Slinging Staging.   FIG. 165.—Ledger-board Fastening.
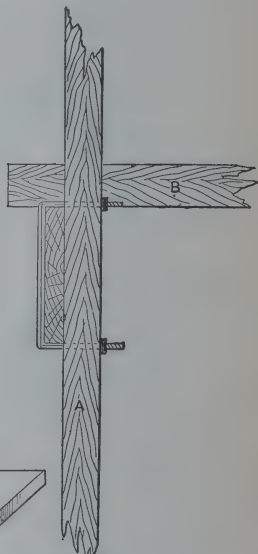
FIG. 163.

Temperatures.—The following table affords a somewhat rough method of estimating high temperature:

	Centi- grade, Degrees	Fahren- heit, Degrees
Just glowing in the dark	525	977
Dark red	700	1252
Cherry-red	908	1666
Bright cherry-red	1000	1832
Orange	1150	2102
White	1300	2372
Dazzling white	1500	2732

The Steel Square.—The standard steel square has a blade 24 inches long and 2 inches wide, and a tongue from 14 to 18

Fig. 166.
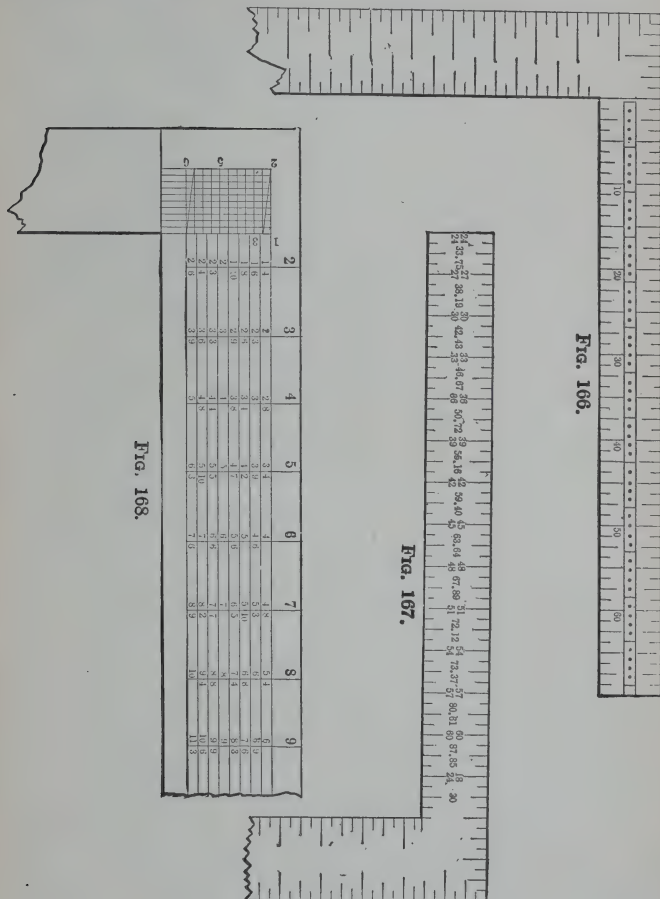
Fig. 167.

Fig. 168.

inches long and 1½ inches wide. The blade is at right angles to the tongue.

In the centre of the tongue will be found two parallel lines

divided into spaces, Fig. 166; this is the octagon scale. The spaces will be found numbered 10, 20, 30, 40, 50, and 60. To draw an octagon, say 12 inches square, draw a square 12 inches each way and draw a perpendicular and horizontal line through the centre. To find the length of the octagon side place the point of the compasses on any one of the main divisions of the scale and the other point of the compasses on the twelfth subdivision; then step this length off on each side of the centre lines on the side of the square, which will give the points from which to draw the octagon lines; the diameter of the octagon must equal in inches the number of spaces taken from the square.

On the opposite side of the tongue will be found the brace-rule, Fig. 167. At the end of the tongue will be found the figures $\frac{24}{24}$ 33.95; the $\frac{24}{24}$ indicates the rise and run of a brace, and 33.95 is the length. The rest of the figures are used in the same way.

On one side of the blade will be found nine lines running parallel with the length of the blade and divided at every inch by cross-lines, Fig. 168; this is the board measure. Under 12 on the outer edge of the blade will be found the various lengths of boards, as 8, 9, 10, 11, 12, etc. For example, we will take a board 10 inches wide and 8 feet long; to find the contents we look under 12 and find 8 between the first and second lines; we then follow this space along until we come to the cross-line under 10, the width of the board, and here we find 6 8, or 6 feet 8 inches, the contents of the board.

At the angle of the blade and tongue will be found the diagonal scale, by which an inch can be divided into one hundred equal parts and any number of these parts can be taken from the scale. For instance, i we want to find $\frac{7}{100}$ of an inch place one point of the compasses on the diagonal line 2 3, at the intersectio of the seventh line from 2, and the other point on line 1 2, which will give $\frac{7}{100}$ of an inch. To find $\frac{53}{100}$ of an inch place the point of the compasses on line 3 2, at the intersection of the third line from 3, and the other point on this third line a the intersection of line 5 5, which gives $\frac{53}{100}$ of an inch. The line 2 6 i inch in length and divided into ten equal parts, then each part ontains $\frac{10}{100}$ of an inch, and at the diagonal will give any number from $\frac{1}{100}$ to $\frac{10}{100}$. The scale is easily understood.

To Lay Out Angles.—Th following tables of angles is to be used in connection with a two-foot rule or a pair of compasses to lay out any angle desired, as shown by Fig. 169.
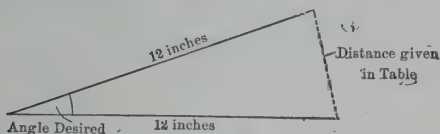
FIG. 169.

Example.—To lay out an angle of 15° take the two 12-inch arms of a two-foot rule and open them 3.13 inches, when the two arms will give the desired angle.

ANGLES AND DISTANCES.

ANGLES AND DISTANCES CORRESPONDING TO THE OPENING OF THE TWO-FOOT RULE.

Angle.	Distance.	Angle.	Distance.	Angle.	Distance.	Angle.	Distance.
Deg.	Ins.	Deg.	Ins.	Deg.	Ins.	Deg.	Ins.
1	.2	24	4.99	47	9.57	69	13.59
2	.42	25	5.19	48	9.76	70	13.77
3	.63	26	5.4	49	9.95	71	13.94
4	.84	27	5.6	50	10.14	72	14.11
5	1.05	28	5.81	51	10.33	73	14.28
6	1.26	29	6.01	52	10.52	74	14.44
7	1.47	30	6.21	53	10.71	75	14.61
8	1.67	31	6.41	54	10.9	76	14.78
9	1.88	32	6.62	55	11.08	77	14.94
10	2.09	33	6.82	56	11.27	78	15.11
11	2.3	34	7.02	57	11.45	79	15.27
12	2.51	35	7.22	58	11.64	80	15.43
13	2.72	36	7.42	59	11.82	81	15.59
14	2.92	37	7.61	60	12	82	15.75
15	3.13	38	7.81	61	12.18	83	15.9
16	3.34	39	8.01	62	12.36	84	16.06
17	3.55	40	8.2	63	12.54	85	16.21
18	3.75	41	8.4	64	12.72	86	16.37
19	3.96	42	8.6	65	12.9	87	16.52
20	4.17	43	8.8	66	13.07	88	16.67
21	4.37	44	8.99	67	13.25	89	16.82
22	4.58	45	9.18	68	13.42	90	16.97
23	4.78	46	9.38				

Bond of Brick in Angles.—Figs. 171 and 172 show how to work the bond of brick in a break of less than 4 inches in a wall. Fig. 171 shows one course of brick and Fig. 172 the next course. The dotted lines in Fig. 172 indicate the course shown by Fig. 171.
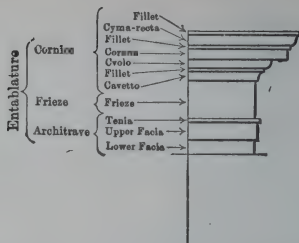
FIG. 170a.—Names of Parts of an Entablature.
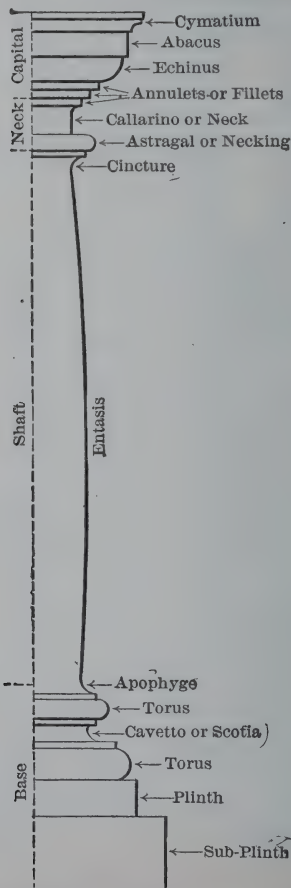
FIG. 170b.—Names of Parts of a Column.

In some of the common brickwork, such as factory buildings, etc., it is often desired to carry up a corner, which is not a
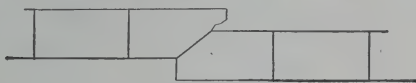
FIG. 171.
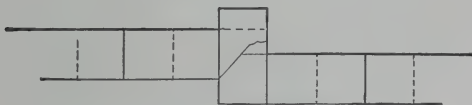
FIG. 172.—Bond in Angles.

right angle, without going to the expense of having special shape brick made or cut. Figs. 173 and 174 show how an octagon corner can be run up with ordinary square brick. Fig. 173 is one course and Fig. 174 is the next succeeding course
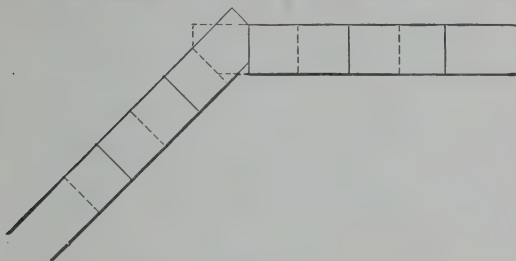
FIG. 173.
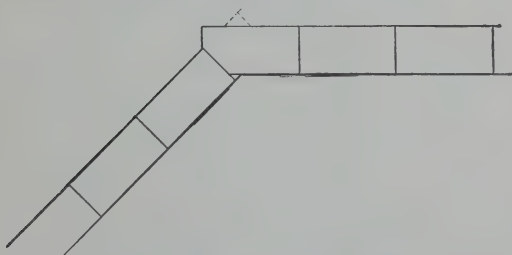
FIG. 174.—Bond of Brick in Angles.

above. The dotted lines in Fig. 174 represent the position of the bricks shown by Fig. 173. If neatly done, a corner of this kind with the corners of the bricks projecting makes a very nice appearance.

Figs. 175 and 176 show another method of carrying up an angle with square bricks. Fig. 175 shows one course of brick
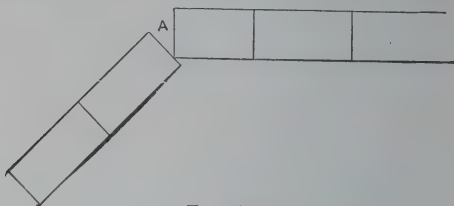
FIG. 175.
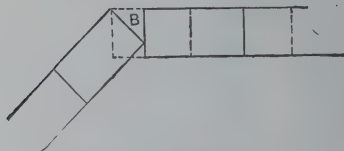
FIG. 176.—Angle-bond.

and Fig. 176 the next succeeding course laid, leaving recesses or "pigeon-holes," as shown at *A* and *B*.
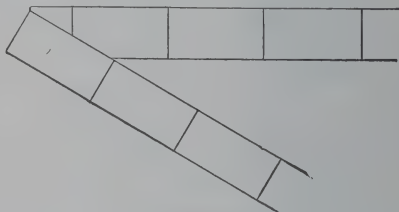
FIG. 177.
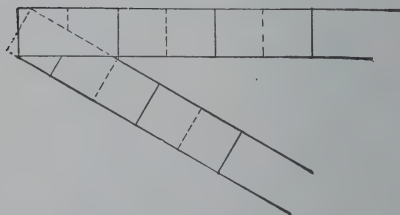
FIG. 178.—Bond in Sharp Angle.

Figs. 177 and 178 show how a sharp or acute angle can be carried up. The alternate courses are shown by Figs. 177 and 178, the dotted lines of Fig. 178 showing the course below.

Running Bond of Brick in Angles.—In an internal angle always work the brick in from the corner or external angle of the wall, and have t e "bat" or clipped brick (if any) work in the angle, as shown by Fig. 1 9. *A* represents one course of brick and *B* the next succeeding course.
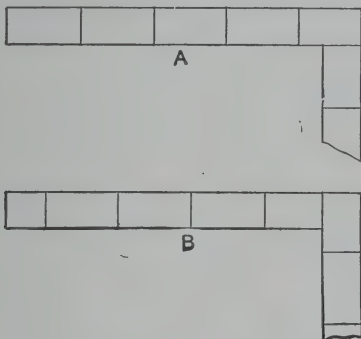
Fig. 179.—Running Bond in Angles.

Bonding New to Old Work.—In building a new wall which butts against or adjoins an old wall some means should be taken to anchor the new work to the old.

A good method is to cut out a few bricks in the old wall and build in iron anchors, or the most common method is to
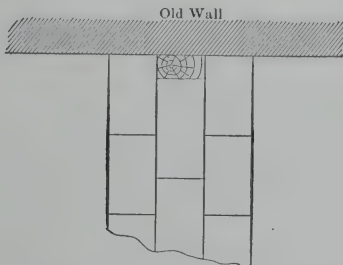
Fig. 180.—Bonding New to Old Work.

spike a $2'' \times 4''$ studding to the old wall and build the new work around it, as shown by Fig. 180.

Flashing.—Lead or tin flashing is often built in the joints of a chimney or fire wall up the rake of the roof as the brick-

work is done, and especial care should be taken to give the pieces of flashing plenty of lap in the wall and to lap over each other so as to be water-tight.
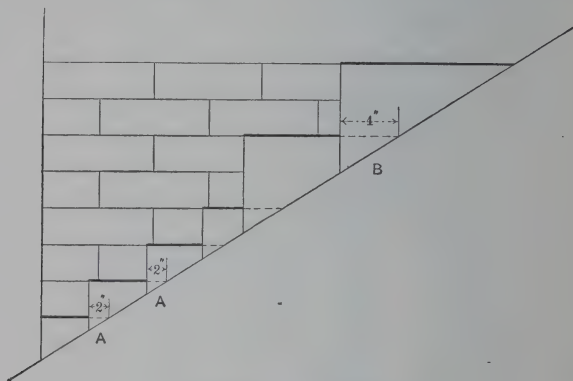
FIG. 181.—Cap Flashing.

They should be built in the wall about $2\frac{1}{2}$ inches, and when stepped up one course of brick at a time the flashing should lap over the one below at least 2 inches, as shown at A, Fig. 181, and when stepped up two courses should lap over the one below 4 inches, as shown at B.

To Turn an Arch Over a Bake-oven or Cistern.—To turn the arch over a bake-oven or cistern, a simple method is to build a scaffold or platform at the spring of the arch and
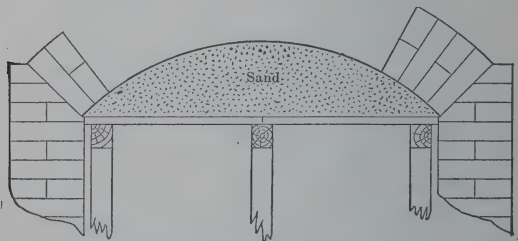
FIG. 182.—Cistern Arch Form.

on this platform form the shape of the crown or arch with sand or earth and on this form build the arch, as shown by Fig. 182.

When the earth or sand is to be taken out through a man-hole or top the boards of the platform should be jointed on the centre bearing as shown, so they will be in short pieces and can be easily removed.

Skew-back of Horseshoe Arch.—In building a horseshoe arch, such as shown by Fig. 183, the skew-back must be cut
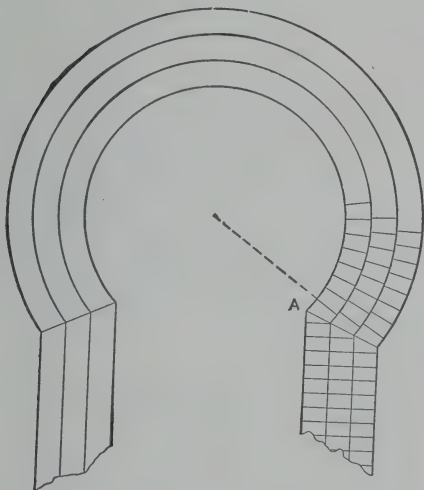
Fig. 183.—Horseshoe Arch.

to suit the intersection of the straight pilaster and the arch, as shown at *A*. The joints of the circle must be kept to radiate towards the centre of the circle or arch, and the first brick of the arch clipped to fit the skew-back, as shown.

Setting Grates.—Grate-setting is usually done by the tile-setter who lays the hearth and sets the tile facing and mantel, but at odd times the brick-mason may be called on to do this work. Fig. 184 shows how the tile back wall of a grate should be put in place. The iron frame which supports the grate should first be fastened in place and the grate set in so as to get the position of the sides and back wall of the ash-pit. This wall is then built up to the required height, usually two or three courses of brick. In the centre of this back wall is

sometimes left an opening about 4 inches square which should have a damper in it to regulate the draft.

The bricks 1 and 2 should then be put in place at each end to support the back tile A, which should be set with a slope
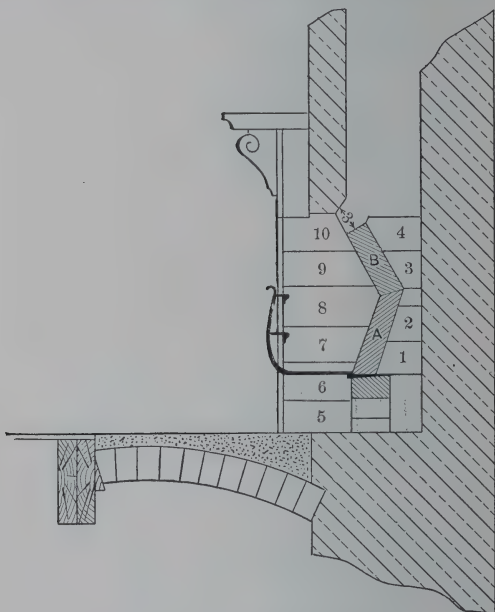
Fig. 184.—Section of Fireplace.
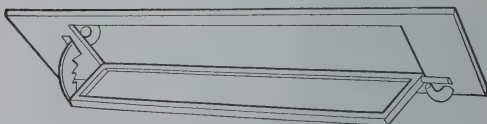
Fig. 185.—Fireplace Damper.

of about 3 inches to a foot or to regulate the throat of the flue to about 3 inches, as shown.

The side bricks 5 to 10 should now be put in place, the top ones being clipped to let the top piece of tile B lay in the position shown and make the throat about 3 inches, as explained.

The wedge brick 3 and 4 are put in place at each end of the tile D by reaching up through the throat of the flue. Cast-iron dampers are often built in the throat to regulate the draft, as shown by Fig. 185. They should be fastened solid and be made so they can be adjusted by a lever or the poker.

To set a grate requires two pieces of tile for back wall, fifteen to twenty fire-bricks, and eight or ten common bricks for backing. The tile and fire-brick should be set in fire-clay.
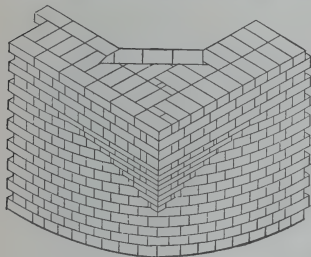
FIG. 186.—Corner Corbel.　　FIG. 187.—Corner Corbel.
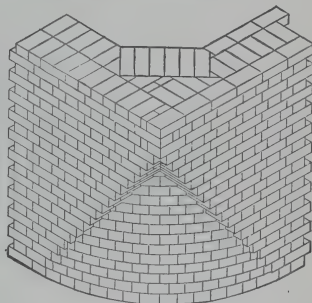
Corbelling Out Corners.—Figs. 186 and 187 show two methods of corbelling out a corner from a circle to a square. By turning the cuts upside down they will show how to draw in from a square to a circle.

Ornamental Work with Plain Brick.

Figs. 188 to 196 show some of the many designs for panels, friezes, etc., that can be produced with common brick, either plain or using brick of two shades or colors. Figs. 188 to 190
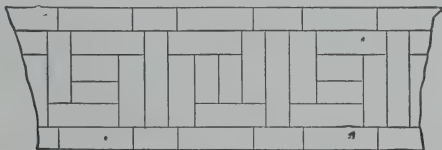
FIG. 188.—Ornamental Brickwork.

are made with bricks of the same color, the design being formed by the joints of the bricks. Fig. 192 is what is called herring-

bone work and makes a very nice design for a panel, etc. Figs. 193 to 196 are made by using two shades of brick, as shown,

Fig. 189.
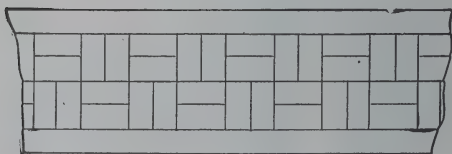
Fig. 190.
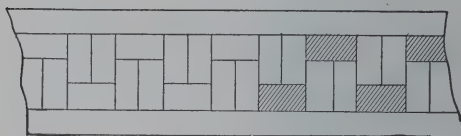
Fig. 191.
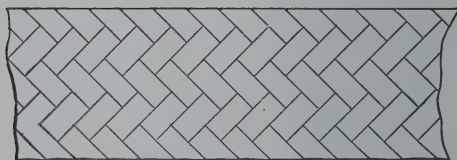
Fig. 192.—Ornamental Brickwork.

or the same effect can be secured by keeping the bricks shaded in the design back about ½ inch from the face of the wall, thus making a sunk design. Fig. 191 can also be worked in this

way, as shown. These are only a few of the many designs that can be made in brickwork, and are only given as example.
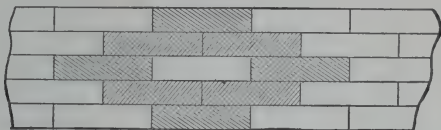
Fig. 193.
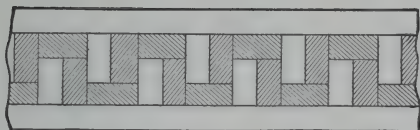
Fig. 194.

Fig. 195.
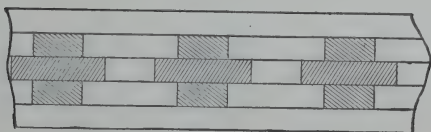
Fig. 196.—Ornamental Brickwork.

CHIMNEY-TOPS.—The following cuts, Figs. 197 to 204, show some of the many designs for chimney-tops that can be worked

out with ordinary square brick. When the chimney extends
to any great height out of the roof the tall appearance can be
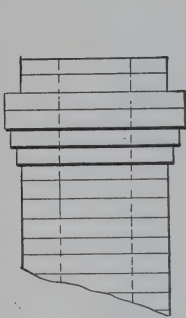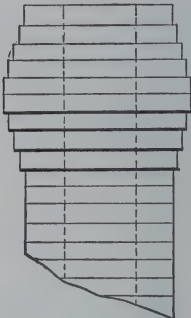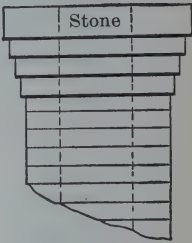
FIG. 197.   FIG. 198.   FIG. 199.
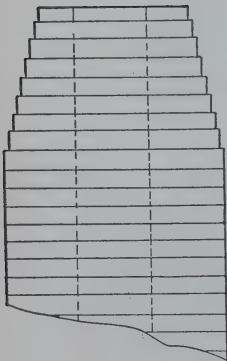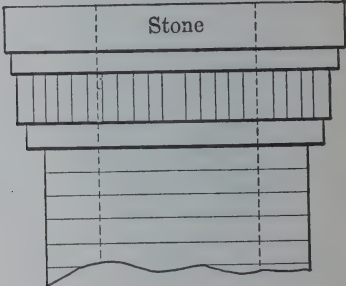
FIG. 200.   FIG. 201.

Designs for Chimney-tops.
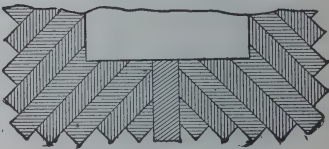
relieved by a projecting ring of a couple of courses of brick, as
shown at A, Fig. 204.
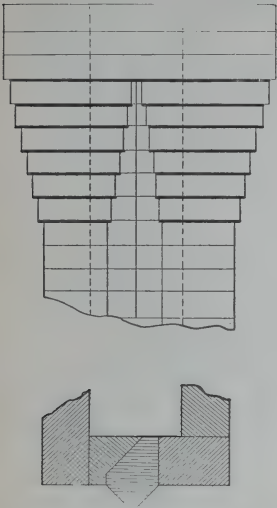
Fig. 202.
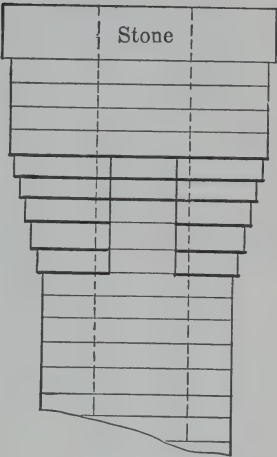
Fig. 203.
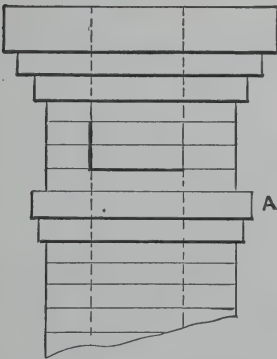
Fig. 204.—Designs for Chimney-tops.

Tools, etc., Used.

To Prevent Boom of Derrick from Sagging. When working a derrick with a long boom which is liable to sag in the
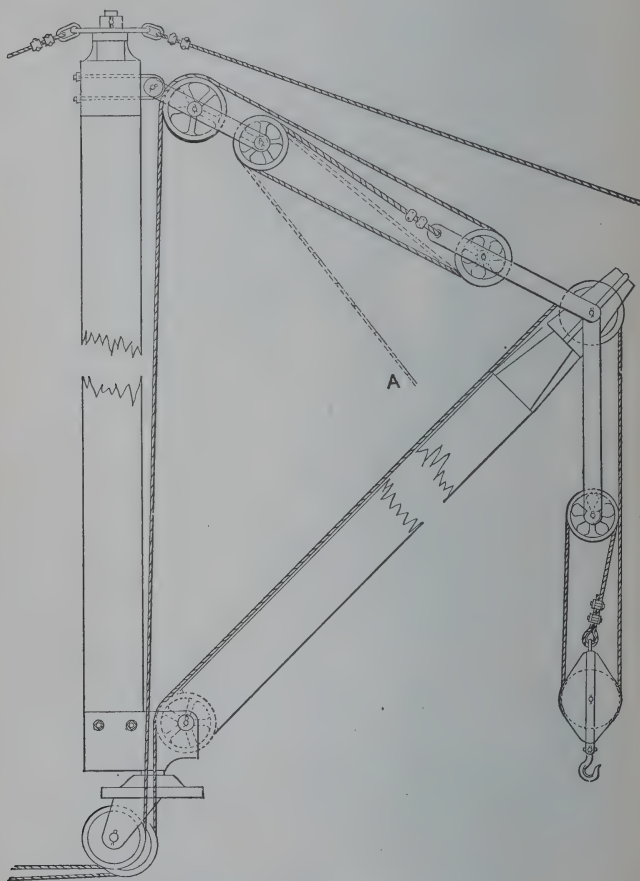
Fig. 205.—Stringing Derrick-boom.

centre or to buckle with a heavy weight, thread up the boom-line, as shown by the dotted lines at A, in Fig. 205 and make

the end of the line fast to the centre of the boom; this will take strain enough on the boom at this point to prevent all sagging.

CHAIN GRAB-HOOKS.—The chain on grab-hooks should be fastened at one end with a shackle and bolt and should have several intermediate large links in the chain, as shown at *A*, Fig. 206, so it can be adjusted to suit various sizes of stones.
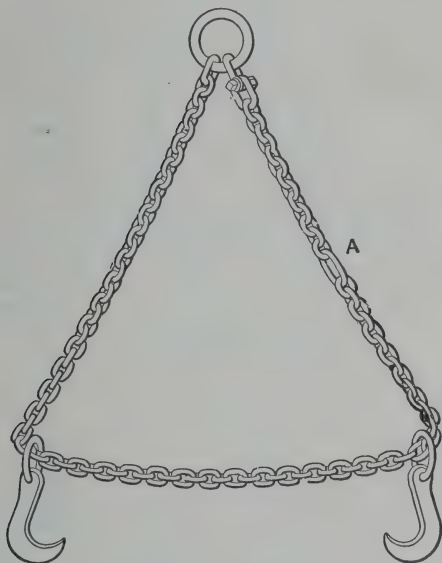
FIG. 206.—Grab-hooks.

Or another method is to have a hook on a piece of chain, as shown by Fig. 207, the hook being made so as to catch the chain between the links. This can then be adjusted to any size stone. On buildings where the stones are of various sizes this is the best style of grab-hooks.

LEWISES.—Figs. 208 to 211 show several styles of lewises for lifting stone. The chain-and-pin lewis, Fig. 210, is mostly used, as the two holes can be drilled in the stone at the quarry with a power-drill.
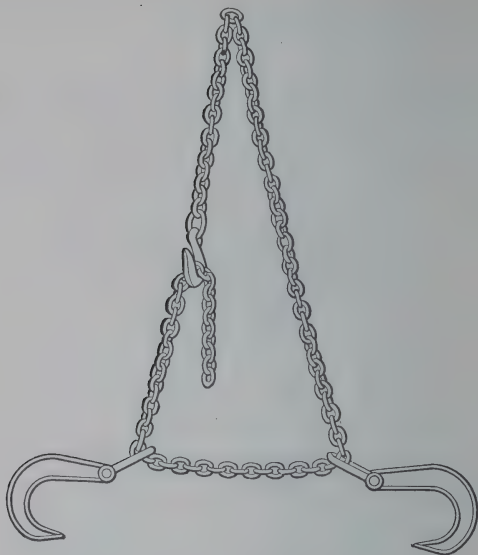
Fig. 207.—Grab-hooks.
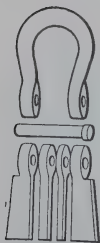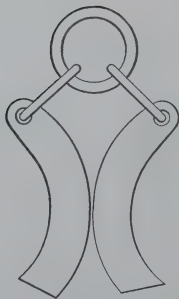
Fig. 208.　　Fig. 209.　　Fig. 210.　　Fig. 211.
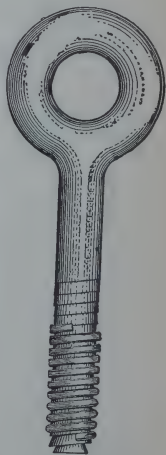
Lewises.

Fig. 211 shows a new lewis or grapple, invented by Harvey Farrington, New York. It consists of an eye-bolt with a
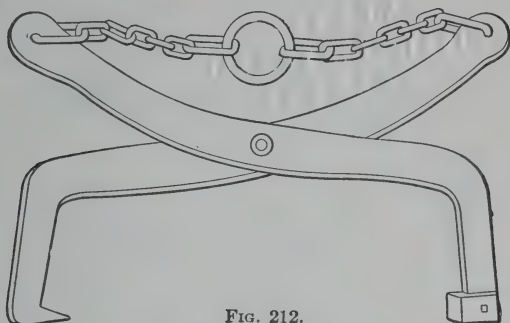
FIG. 212.
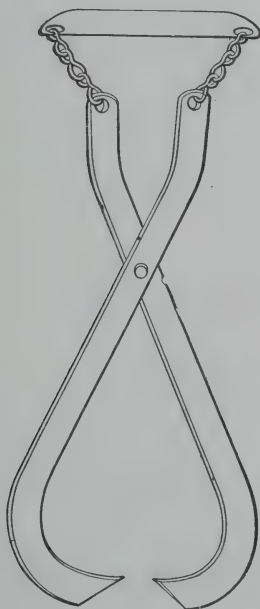
FIG. 213.—Stone Tongs.

tapered thread and a spiral coil of wire. The strain on the bolt causes the spiral coil of wire to expand and grip the sides of the

hole in which it has been inserted. This grapple requires but one hole in the centre of the stone. A 1-inch grapple has been tested to lift 17,663 pounds.
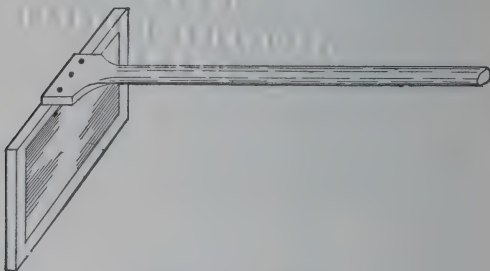
FIG. 214.—Hand Mirror.

Figs. 212 and 213 show two styles of hooks or tongs of which there should be several sizes on any job where many stones are to be hoisted, so as to be able to catch the various thicknesses and sizes of stones.

MIRROR FOR SETTING CAPSTONE OF CORNICE.—When setting the top or cap stone of heavy stone cornice, such as shown in Fig. 44, page 16, the mason will have much trouble to look under the stone to note the position of it and see how the joints are.
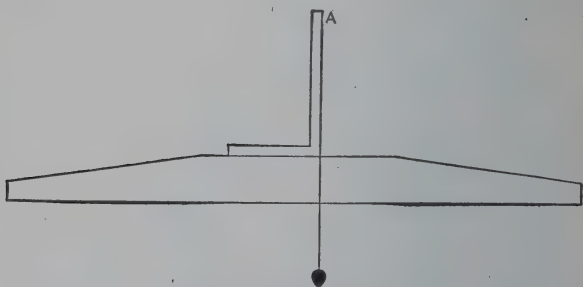
FIG. 215.—Levelling with a Square.

A contrivance to overcome this difficulty is made by screwing a handle to a looking-glass, as shown by Fig. 214. The mirror can then be held below the stone and the reflection will

show the soffit and joints beneath it, which cannot be seen from above.

To Use the Square to Level with.—To level with a square and plumb-bob place the square on the straight-edge, as shown by Fig. 215, and drop the plumb-bob, holding the line at the top of the blade of the square, as at A, Fig. 215. With the eye sight the bob-line with the square, and they will show in line when the straight-edge is level.

To Use the Square to Plumb with.—To plumb with a square set the blade of the square against the object to be plumbed and use the level on the tongue; when the tongue shows level the blade of the square will be plumb.

Care of a Rope.—When coiling a rope always coil around to the right; this has a tendency to take out all twists and kinks, while if it is coiled to the left the coiling will twist and kink the rope. When rigging up a derrick or using ropes (except new ones) for any purpose, carefully examine them before putting them into use to ascertain their condition. Often a rope will look all right on the outside, while the interior of the rope may be rotten. Open up the twist of the rope and examine the different strands carefully in several places in the length of the rope.

Do not put a wet rope away in storage until it has been dried and aired well. A little precaution will lengthen the life of a rope considerable.

When opening a coil of new rope (especially wire rope) take the coil and run it along the ground like a wheel, letting the rope stretch out behind. This will prevent twists and kinks. After a hemp or manila rope has had some use it will be flexible enough to run directly off the coil, but a wire rope must always be run off, as explained above.

Several months' use of a rope usually decreases its strength about 40 per cent.

Setting Cut Stone.—When setting cut stone use a stone-cutter's mallet instead of a hammer and block of wood; it is much handier and will save time.

Tool for Rubbing Stone.—A handy tool for rubbing stone is made by taking a piece of cast iron about 10×12 inches and 1 inch thick. Lay the plate off into squares about $1\frac{1}{2} \times 1\frac{1}{2}$ inches, and at each intersection drill a $\frac{1}{2}$-inch hole. Around the plate put a rim extending up about 1 inch above the top of the plate, and put a handle on top of the plate to lift it by and to use in

sliding the plate back and forth over the stone to be rubbed. Fill the plate to the top of the rim with sand and wet with water, and rub same as rubbing with a piece of stone. The sand will go down through the holes in the plate and cut very fast.

FILLING IN BEHIND GREEN WALLS.—Do not fill in behind brick or stone foundation- or retaining-walls until the mortar is hardened or the weight of the building is on the wall; otherwise the pressure of the earth filling may cause the wall to bulge out of plumb.

PART IV.

STRENGTH, WEIGHT, ETC., OF VARIOUS
BUILDING - STONES. COMPOSITION AND
ANALYSIS OF VARIOUS BUILDING-STONES.
STRENGTH, ETC., OF WOODEN POSTS AND
BEAMS. STRENGTH, ETC., OF IRON AND
STEEL COLUMNS AND BEAMS. STRENGTH,
WEIGHT, ETC., OF VARIOUS BUILDING-
MATERIALS.

Strength, Weight, Etc., of Various Materials.

STRENGTH AND WEIGHT OF VARIOUS GRANITES.

State.	Location.	Strength per Sq. Inch.	Weight per Sq. Foot.
Arkansas.........	Pulaski Co. (gray granite).........	14,000	...
"	Fourth Mountain (syenite)........	30,740	167
California........	Rocklin........................	30,740	167
Colorado........	Gunnison.......................	12,976	165
"	Platte Canyon (red).............	14,585	168
Connecticut......	Middleton......................	21,460	...
"	Waterford......................	23,510	...
"	Meriden (trap rock).............	34,920	...
"	Kirkland rocks..................	35,000	166
"	Lord's Island..................	24,000	...
"	Mystic River...................	22,250	164
"	New Haven.....................	9,750	...
"	Millstown Point	16,187	169
"	Milford........................	22,600	...
"	New London....................	12,500	166
Georgia.........	Lithonia.......................	25,630	...
Maine..........	Hurricane Isle..................	19,538	167
"	Jonesboro (red).................	24,507	...
"	Waldoboro (white)..............	23,111	...
"	North Jay (red)................	22,367	...
"	Dix Island.....................	15,000	166
"	Fox Island (blue)...............	15,000	164
"	Sharkey's Quarry...............	22,125	170
"	Vinalhaven (gray)...............	17,000	...
Massachusetts....	Cape Ann......................	20,296	164
"	Milford (pink)..................	30,888	...
"	Milford (Norcross Bros.).........	20,883	...
"	Quincy (dark)..................	17,750	166
"	Quincy (light)..................	14,750	166
"	Fall River (gray)...............	15,937	...
Michigan........	Huron Island...................	18,125	164
Missouri.........	Graniteville....................	24,181	...
Minnesota.......	East St. Cloud.................	28,000	168
"	Duluth (dark)..................	17,631	175
"	Duluth (light)..................	19,000	...
New Hampshire..	Troy..........................	17,950	168
"	Keene (blue gray)...............	12,000	166
New York.......	Goshen........................	23,500	...
"	Staten Island (blue).............	22,250	178
"	Tarrytown......................	18,250	162
New Jersey......	Scotch Plains (trap rock)........	17,950	...
"	Passaic Co. (gray)..............	24,040	...
"	Jersey City....................	20,750	189
Rhode Island....	Westerly (gray).................	17,500	165
South Carolina...	Carlisle.......................	29,150	...
Texas...........	Burnet Co.....................	11,891	176
Vermont........	Barre (dark)...................	19,975	...
"	Barre (light)...................	17,856	...
Virginia........	Peters.........................	25,100	...
"	Richmond.....................	25,520	...

The argillaceous is a soft stone cemented with a clayey matter

STRENGTH AND WEIGHT OF SANDSTONES.

State.	Location.	Color.	Strength per Sq. Inch.	Weight per Sq. Foot.
Arizona	Flagstaff.	Chocolate	5,857	142
California	Colusa.	. . . .	8,880	. . .
Colorado.	St. Vrains.	Red.	11,500	149
"	Fort Collins	Gray.	11,707	140
"	Manitou.	Red.	11,000	140
Connecticut. . . .	Portland.	. . . .	10,871	148
"	Middletown.	Brown.	6,950	. . .
"	Cromwell.	. . . .	16,890	156
Indiana.	Riverside.	Gray.	6,000	. . .
"	"	Blue	6,090	. . .
Iowa	La Grande.	. . . .	6,805	. . .
Kansas.	Valley Falls	. . . .	7,500	152
Kentucky.	Langford	. . . .	15,160	. . .
Massachusetts. .	East Longmeadow. .	Red.	11,595	154
Missouri.	Warrensburg.	Blue-gray.	9,687	149
Minnesota.	Kasota.	Pink.	10,700	164
"	Kettle River. . . . . . . :	Pinkish buff. . .	17,000	139
"	Frontenac.	Buff.	6,250	145
Michigan.	Redrock.	. . . .	6,019	. . .
"	Portage Entry (Lake Superior).	Red.	6,776	126
"	Marquette	. . . .	7,450	158
New York	Potsdam.	Red.	18,401	162
" "	Medina.	Pink.	17,250	150
" "	Oxford.	Blue	12,677	. . .
" "	Warsaw	Blue	19,968	167
" "	Albion.	Brown.	13,500	157
" "	Little Falls.	Brown.	9,850	. . .
" "	Haverstraw.	Red.	4,350	133
New Jersey . . .	Belleville	Gray.	11,700	147
"	. . . .	Brown.	13,310	148
North Carolina .	Carthage.	. . . .	12,750	. . .
Ohio.	Seneca.	Reddish brown	5,000	134
"	Lancaster.	. . . .	5,950	. . .
"	Amherst	Buff.	9,450	133
"	Berea	Dark drab. . . .	9,510	134
"	Cleveland	Olive-green. . .	6,800	140
"	Vermillion.	Drab.	8,850	135
"	Massilon	Yellow-drab. . .	8,750	. . .
Pennsylvania. .	Hummelstown.	Brown.	13,097	. . .
" . .	Laurel Run.	. . . .	22,250	166
" . .	White Haven.	. . . .	29,250	. . .
South Dakota . .	Hot Springs	. . . .	6,914	. . .
" " . .	Rapid City.	Gray.	11,452	. . .
" " . .	"	Red.	6,116	. . .
Washington	Chuckanut.	. . . .	10,276	. . .
Wisconsin.	Fon du Lac.	Purple.	6,237	138
Wyoming	Rawlins	. . . .	10,883	. . .

RATIO OF ABSORPTION OF STONES.

Kind of Material.	Maxi-mum.	Mini-mum.	Aver-age.	Kind of Material.	Maxi-mum.	Mini-mum.	Aver-age.
Granites	$\frac{1}{150}$	0	$\frac{1}{750}$	Sandstones . . .	$\frac{1}{15}$	$\frac{1}{240}$	$\frac{1}{24}$
Marbles.	$\frac{1}{150}$	0	$\frac{1}{300}$	Bricks.	$\frac{1}{4}$	$\frac{1}{50}$	$\frac{1}{10}$
Limestones. . .	$\frac{1}{20}$	$\frac{1}{500}$	$\frac{1}{38}$	Mortars.	$\frac{1}{2}$	$\frac{1}{10}$	$\frac{1}{4}$

Strength and Weight of Various Limestones.

State.	Location.	Strength per Sq. Inch.	Weight per Cu. Foot.	State.	Location.	Strength per Sq. Inch.	Weight per Cu. Foot.
Ark.	Johnston	15,500	....	Mich.	Lime Island	18,000	....
Ill.	Kankakee	13,544	165	Mo.	Carthage (white)	14,950	185
"	Joliet (white)	14,775	160	"	Cooper Co. (dark		
"	Quincy	9,687	160		drab)	6 650	141
"	Grafton	17,000	....	N. Y.	Glens Falls	11,475	168
Ind.	Bedford	6,000	154	"	Lake Champlain	25,000	171
"	Bloomington	4,100	....	"	North River	11,475	169
"	Salem	9,000	156	"	Canajoharie	20,700	168
"	Stinsville	5,600	....	"	Erie Co. (blue)	12,250	165
Iowa	La Grande	10,825	....	"	Kingston	13,900	168
"	Stone City	11,250	136	"	Garrison	18,500	165
Kan.	Marion	12,364	168	Ohio	Marbleh'd (w'e)	12,600	150
Ky.	Warren Co.	6,795	....	Wis.	Sturgeon Bay		
"	Bardst'n (da'k)	16,250	168		(blue)	21,500	174
Minn.	Winona	16,250	160	"	Waukesha	8,880	....
"	Stillwater	15,000	172	Pa.	Avondale (gray)	18,000	....
"	Redwing	23,000	162	"	(light)	12,112	....
				"	Conshohocken.	15,000	....

CHEMICAL COMPOSITION, WEIGHT, AND CRUSHING STRENGTH OF VARIOUS MARBLES.

State.	Location.	Carbonate of Lime.	Iron.	Carbonate of Magnesia.	Insoluble.	W'ght per Square Foot.	Crushing Str'ng'h per Square Inch.
Cal.	Inyo	78.36	.017	21.79	2.6	.....	29,000
"	Colton	92.9	.....	4.5	2.6	.....	9,350
"	Beulah	98 00	.04	.05	.06	.....	
Ga.	Cherokee	98.96	.....	.13	.61	171	10,970
"	Creole	98.	.....	.26	.50	172	12,078
"	Etowah	97.32	.26	1.60	.62	169	10,642
Ill.	Mill Creek	.....	.....	.....	.....	172	9,687
Md.	Cockysville	.....	.....	.....	.....	178	23,500
Mass.	Lee	69.64	.....	27.98	1.00	.....	18,047
"	Westfield	79.68	.....	19.68	.20	.....	21,820
"	Great Barrington	98.34	.14	.50	.38	.....	10,910
"	Hastings	52.82	.....	45.78	.....	.....	18,941
N. Y.	South Dover	77.29	.....	20.25	.90	.....	18,836
"	East Chester	.....	.....	.....	.....	179	13,500
"	Pleasantville	54.12	.....	45.04	.10	.....	12,692
"	Sing Sing	53 24	.....	.....	45.89	.....	
Pa.	Annville	95.10	.23	3.96	1.07	.....	12,210
"	Montgomery (blue)	98.15	.54	.50	.77	180	18,000
Tenn.	East Tennessee	98.78	.26	.67	.08	.....	15,750
Vt.	Proctor	98.37	.03	.77	.63	.....	
"	Rutland (white)	97.73	.59	.....	1.68	166	10,746
"	Rutland (green)	85.45	14.55	.....	.....	.....	
"	Dorset	.....	.....	.....	.....	165	7,612
Va.	Montgomery	.....	.....	.....	.....	.....	8,950
Wis.	North Bay	.....	.....	.....	.....	175	20,025

CRUSHING STRENGTH OF STONES, ETC.

Material.	Crushing Strength in Pounds per Sq. Inch. From	To
Lee, Mass., marble...................	20,504	2,900
Potomac red sandstone....................	16,625	22,102
Coshohocken, Pa., limestone.............	14,090	16,340
Hummelstown, Pa., sandstone............	12,810	13,610
Montgomery Co., Pa., blue marble.........	9,590	13,700
Philadelphia pressed bricks..............	7,210	9,050
Indiana limestone.	7,190	10,620
Philadelphia hard bricks................	5,540	20,830
Ohio sandstone.........................	3,940	16,280
Brick masonry in cement mortar...........	1,600	2,685
Brick masonry in lime mortar.............	799	1,914

SPECIFIC GRAVITY, WEIGHT, AND CRUSHING STRENGTH
OF BRICK.

Name.	Specific Gravity.	Weight per Cubic Foot in Pounds.	Crushing Strength per Square Inch in Pounds.
Best pressed.	2.4	150	5,000 to 14,973
Common hard.	1.6 to 2.0	125	5,000 to 8,000
Soft.	1.4	100	450 to 600

The New York Building Code gives the working strength
of brickwork as follows:

	Pounds per Sq. Inch.
Brickwork in Portland-cement mortar: cement, 1; sand, 3..	208
Brickwork in lime and cement mortar: cement, 1; lime, 1; sand, 6.	160
Brickwork in lime mortar: lime, 1; sand, 4.	111

WEIGHT OF BRICKWORK.

Placing the weight of brickwork at 112 lbs. per cubic foot,
the weights per superficial foot for different walls are as follows:

For 9-inch wall.....................	84 lbs.
For 13-inch wall....................	121 "
For 18-inch wall....................	168 "
For 22-inch wall....................	205 "
For 26-inch wall....................	242 "

CHEMICAL ANALYSIS OF VARIOUS SANDSTONES.

State	Location	Quarry	Silica.	Oxide of Alumina.	Oxide of Magnesia.	Oxide of Sodium.	Carbon.	Oxide of Potassium.	Ferric Oxide.	Oxide of Calcium.	Water and Loss.
Arizona.	Flagstaff.	Arizona Sandstone Co.	79.19	1.30	.23		5.77		2.45	7.76	.32
California.	Colusa.	Colusa Stone Co.	85.99	4.82	.76				4.49	1.87	.69
Connecticut.	Cronwell.	N. E. Brown Stone Co.	70.84	13.15		5.43	1.01	3.30	2.48	3.09	1.01
	Portland.	(Brown stone).	69.94	13.15					2.48	3.09	
Indiana.	Riverside.	Guyer & Burchby.	93.16	1.60					2.64	.13	
"	St. Anthony.	J. H. Lynn.	88.41	.63			.10		8.40	.13	
"	Williamsport.	Williamsport Stone Co.	98.57	.05			.02		.65	.02	
Kansas.	Valley Falls.	J. M Ginty.	94.35	2.35	1.01					1.14	
Kentucky.	Rock Castle.	Rock Castle Blue Stone Co.	91.07	4.92					.27	1.18	2.36
Maryland.	Frostburg.	B. Randolph.	99.40	.47					.28	.10	.99
Michigan.	Lake Superior.	Portage Entry Quarries Co.	85.60	8.32	.18	.53			3.54	.55	
Massachusetts.	E. L'gmeadow.	Norcross Bros.	81.38	9.44	.28			2.91	1.79	.76	1.83
	Worcester.		98.89	.95						.27	
Minnesota.	Fon du Lac.	Minnesota Sandstone Co.	98.69	1.06	.01	.17				.42	
	Kettle River.		78.24	.88					3.83	.95	.71
New Jersey.	Avondale.	Passaic Quarry Co.	82.05	5.27	.76	.20	4.40	.60	2.71	3.35	1.93
New York.	Oxford.	F. G. Clark Co.	77.56	10.65	1.22	.90		2.15	4.59	.34	2.00
"	Stoneco.	Hudson River Stone Co.	63.24	19.52	1.29				6.35	3.80	
"	Rock Glenn.	Warsaw Blue Stone Co.	76.50	14.75	2.63				4.16	3.92	
N. Carolina.	Carthage.	A. H. M'Neal.	79.63	7.16	.97		2.72	4.66	2.30	1.86	
Ohio.	Amherst.		97.00						1.68	1.15	.20
"	Berea.		96.00		.08				.51	.05	.21
"	Massilon.	Chippewa Stone Co.	97.36	2.28					1.00	.12	.51
"	Lancaster.	F. C. Neeb.	97.76	.73							
"	Euclid.		95.00	2.50							
"	Grafton.		87.66	1.72							
Oregon.	Chitwood.	Victor Sandstone Co.	72.45	12.60	.17				3.52	4.10	2.03
"	Forest Grove.	Forest Grove Stone Co.	55.21	17.87	.44				10.80	2.19	1.50
Pennsylvania.	Hummelsto'n.	Hum'town Bluestone Co. (blue)	90.34	4.35	.22	.19			14.75	.95	.61
"	Do. do.	Do. do. (brown)	98.86	4.74	1.00	.24			1.09	.86	.87
"	Swarta.	Swarta Stone Co.	91.52	3.80				1.30	2.19	.50	1.92
"	Laurel Run.	Laurel Run Stone Co.	94.00					1.31	2.02	1.10	
"	White Haven.	Pennsylvania Quarry Co.	90.36	2.17				1.20	1.15	2.00	.16
"	Lathrop.	Frank Carlucci.	91.40	6.64					.16		3.28
Utah.	Jennings Spur.	Kyune Gray Stone Co.	83.64	.46	.70				1.96	8.50	.22
Wisconsin.	Ashland.	Prentice Stone Co.	91.40	3.53		.14		2.36	2.00	.25	.05

CHEMICAL ANALYSIS OF VARIOUS LIMESTONES.

State.	Location.	Quarry.	Carbonate of Calcium.	Carbonate of Magnesia.	Ox. Iron & Alumina.	Silica.	Oxide of Calcium.
Ill.	Quincy.	F. W. Menke Stone Co.	92.77	6.75	.27	15.90	....
"	Lemont.	....	45.80	....	9.30	15.90	....
"	Joliet.	....	....	....	....	....	....
Ind.	Bedford	Bedford Quar. Co.	98.20	.39	.39	.63	....
"	"	" " " (blue)	97.26	.37	.49	1.69	....
"	Spencer.	....	96.80	.11	.91	.70	....
"	Clear Creek.	Acme Stone Co.	97.37	.78	.13	.84	.10
"	Peru.	J. N. Hurtz.	52.90	38.94	1.25	4.05	....
Iowa.	Monmouth.	L. B. Stewart Co.	57.54	41.51	....	.42	....
Kan.	Marion.	I. Kuhn & Co.	91.50	1.62	1.24	5.51	....
Ky.	Warren Co.	Caden Stone Co.	54.80	....	.22	.76	....
"	Bowling Green	....	95.31	1.12	.39	1.42	....
Mich.	Trenton	Sibly Quarry Co	98.53	.53	.06	.60	....
Minn.	Kasota.	....	49.16	37.53	1.09	13.06	....
"	Stillwater.	....	50.22	37.39	.78	8.74	....
"	Frontenac.	....	54.78	42.53	.67	2.73	....
Mo.	Carthage.	Myers Stone Co	98.57	.65	.21	.69	....
N. Y.	Cobbleskill.	Cobbleskill Quarry Co.	41.90	1.65	.97	4.31	51.05
"	Amsterdam.	....	42.64	....	1.08	3.82	52.46
Ohio.	Cold Springs.	Casparis Stone Co	54.05	44.94	.23	.49	....
"	Tiffin.	....	....	40.36	.10	1.61	57.44
"	Dayton.	....	92.40	1.10	.58	1.70	....
"	Springfield.	....	54.70	44.93	.20	.10	....
Pa.	Youngstown.	Carbon Limestone Co.	96.43	.40	1.60	1.50	....
"	Norristown.	Wm. Rambo.	53.49	45.76	....	.70	....
R. I.	Lime Rock.	Herbert Harris	88.23	8.79	.32	2.74	....
W. Va	Marlow.	G. C. Ditto.	....	.98	.26	.18	98.44
Wis.	Hamilton.	Hamilton Stone Co.	54.25	44.48	.10	.67	....

PRODUCTION AND USE OF MARBLE QUARRIED IN THE U. S. DURING 1901.

State.	Rough.	Building.	Orna-m'tal.	Cemetery.	Interior.	Other.	Total.
Alaska	$4,500	....	.....	....	....	.....	$4,500
Arizona	300	....	.....	....	....	.....	300
Arkansas	200	....	$100	....	....	.....	300
California	3,280	$1,550	1,812	....	....	.....	6,642
Georgia	268,761	241,683	16,500	$207,305	$166,305	$36,000	936,549
Maryland	8,100	45,000	.....	15,000	....	.....	68,100
Massachusetts	63,556	26,220	3,700	9,560	15,051	8,459	126,546
Missouri	....	....	.....	2,100	....	.....	2,100
Montana	....	....	.....	1,500	....	.....	1,500
New Mexico	4,200	3,000	300	3,100	....	.....	10,600
New York	2,367	132,943	4,900	204,289	28,000	6,660	379,159
Oregon	....	....	.....	500	....	.....	500
Pennsylvania	18,078	111,069	.....	25,060	400	2,940	157,547
Tennessee	162,513	13,000	.....	14,000	305,124	.....	494,637
Utah	320	....	.....	....	....	.....	320
Vermont	53,892	659,200	94,450	1,452,434	493,607	.....	2,753,583
Washington	1,600	2,358	4,814	14,044	....	.....	22,816
Totals	591,667	1,236,023	126,576	1,948,892	1,008,482	54,059	4,965,699

CHEMICAL ANALYSIS OF GRANITES FROM VARIOUS QUARRIES.

State	Location	Quarry	Silica	Oxide of Alumina	Oxide of Magnesia	Oxide of Sodium	Oxide of Potassium	Oxide of Iron	Oxide of Calcium
California	Exeter	Rocky Point Granite Works.	75.35	13.69	.06	1.14	2.85	3.94	2.97
Connecticut	Waterford	Hurricane Isle Granite Co.	68.11	14.28	.68	6.57	5.46		1.86
	Meriden	(Trap rock).	52.37	15.06	5.38	4.04			7.33
Delaware	Rockford	Brandywine G't Co. (gneiss).	67.98	16.14	.53	4.32	.45		5.89
Maine	Waldoboro	Booth Bros	73.48	15.26	.09	3.12	5.66		.98
	North Jay	Maine and N. H. Granite Co.	71.54	14.24		3.39	4.73		.94
	Blue Hill	Chase Granite Co.	73.02	16.22		3.60	3.42		.39
	Blue Hill	Blue Hill Granite Co.	74.64	14.90		.41	6.88		3.73
Maryland	Point Deposit	M'Clenahan Bros.	73.69	12.89	.49	2.81	1.48		4.77
Minnesota	East St. Cloud		65.12	16.96		5.25		4.69	1.10
Massachusetts	Cape Ann	Rockport Granite Co.	81.05	14.70		5.60	5.03		.85
"	Milford	Shea Pink Granite Co.	76.95	11.15	.10	3.37	4.71		9.05
"	Milford	Norcross Bros.	76.07	12.67	.28				4.48
"	Monson	(Trap rock).	52.59	23.42					5.94
"	Monson	Light granite.	73.47	15.07		5.97	2.69	1.15	5.68
"	Monson	Dark granite.	69.35	18.23		3.78	.89	2	.81
Nevada	Reno	Jno. Barret.	58.67	14.89	1.79	7.68	.71		1.65
N. Hampshire	Red Stone	N. H. Granite Co. (red).	71.44	14.72	.96	7.66	5.74		
"	"	" " (green).	70.42	14.64	1.20	7.80	4.83		
"	Troy	Troy Granite Co.	73.15	17.04	.30	2.05	1.71		
"	Mason	Mason Granite Co.	72.47	16.17	.14	3.43	4.01		
New Jersey	Little Falls	Franceseo Bros. (trap).	50.81	13.25	6.97	.76	2.01		10.96
New York	Stormy P't.	Daniel Donovan	63.19	10.50	1.43	1.91	4.31		6.12
Pennsylvania	Birdsboro.	John T. Dyer Co.	46.87	13.36	4.35	4.64	4.82		14.76
Vermont	Barre.	Wells, Lamson & Co.	69.56	15.38		5.38	3.80		1.76
Virginia	Petersburg.	Petersburg Granite Co.	64.12	20.91	.66	4.57	6.38	2.96	1.98
	Richmond.	P. Copeland.	60.65	16.87	2.39	2.18	1.86		1.91
Wisconsin	Waushara Co.	Milwaukee Monument Co.	76.62	13.02	.05	2.24			.51
"	Berlin.	E. J. Nelson.	73.65	11.19	.51	3.74			2.78

SAFE LOADS FOR RECTANGULAR WOODEN PILLARS (SEASONED).

l = length of pillar in inches;
d = width of smallest side in inches.

Yellow Pine (Southern).	White Oak.	White Pine and Spruce.
$\dfrac{1125}{1+\dfrac{l^2}{1100d^2}}$	$\dfrac{925}{1+\dfrac{l^2}{1100d^2}}$	$\dfrac{800}{1+\dfrac{l^2}{1100d^2}}$

These formulæ give safe loads of one-fourth the ultimate strength for short pillars, decreasing to one-fifth the ultimate for long pillars.

Ratio of Length to Least Side $\dfrac{l}{d}$.	Safe Loads in Pounds per Square Inch of Section.		
	Yellow Pine (Southern).	White Oak.	White Pine and Spruce.
12	995	818	707
14	955	785	679
16	913	750	649
18	869	715	618
20	825	678	587
22	781	642	556
24	738	607	525
26	697	575	495
28	657	541	467
30	619	509	440
32	583	479	414
34	549	451	390
36	516	425	367
38	487	400	346
40	458	377	326

SHRINKAGE OF TIMBER.

Cedar.	12 to 11.40	inches
Elm.	12 to 11.70	"
Oak.	12 to 11.75	"
Pine (white).	12 to 11.80	"
Pine (yellow).	12 to 11.90	"
Pine (yellow long-leaf).	12 to 11.95	"
Redwood (California).	12 to 11.95	"
Spruce.	12 to 11.85	"

SAFE LOADS IN TONS OF 2000 POUNDS FOR SQUARE WOODEN
PILLARS.

Unsupported Length of Column in Feet.	Size of Pillar in Inches.						
	6×6	8×8	9×9	10×10	12×12	14×14	16×16
	WHITE PINE OR SPRUCE.						
6	12.80	....	....	....	....	....	....
8	11.70	22.7	29.6	....	....	....	....
10	10.60	21.3	28.0	35.5	....	....	....
12	9.54	19.8	26.3	33.7	51.1	....	....
14	8.46	18.4	24.7	31.9	49.0	69.6	....
16	7.38	17.0	23.1	30.1	46.8	67.0	91.0
18	....	15.5	21.5	28.3	44.7	64.5	88.0
20	....	14.1	19.8	26.5	42.5	62.0	85.2
22	....	....	18.2	24.7	40.3	59.5	82.3
24	....	....	....	22.9	38.2	57.0	79.4
	WHITE OAK.						
6	14.80	....	....	....	....	....	....
8	13.50	26.2	34.0	....	....	....	....
10	12.20	24.6	32.4	41.0	....	....	....
12	11.00	22.7	30.4	39.1	59.1	....	....
14	9.73	21.1	28.4	36.7	56.9	80.4	....
16	8.64	19.5	26.5	34.6	54.0	77.8	105.0
18	....	17.8	24.7	32.4	51.1	74.5	102.0
20	....	16.3	22.7	30.5	49.1	71.3	98.5
22	....	....	21.1	28.2	46.1	68.3	94.7
24	....	....	....	26.4	43.9	65.5	90.9
	YELLOW PINE (SOUTHERN).						
6	18.0	....	....	....	....	....	....
8	16.4	32.0	41.6	....	....	....	....
10	14.9	29.9	39.4	50.0	....	....	....
12	13.3	27.8	36.9	47.6	72.0	....	....
14	11.9	25.8	34.7	44.7	69.1	98.0	132.0
16	10.4	23.7	32.3	42.3	65.5	94.6	128.0
18	....	21.8	30.0	39.5	62.6	90.7	124.0
20	....	19.8	27.8	37.0	59.8	86.9	120.0
22	....	....	25.7	34.6	56.2	83.6	115.0
24	....	....	....	32.2	53.3	80.0	111.0

SAFE LOADS UNIFORMLY DISTRIBUTED FOR RECTANGULAR SPRUCE OR WHITE-PINE BEAMS ONE INCH THICK.

The following table has been calculated for extreme fibre stresses of 750 pounds per square inch corresponding to the following values for moduli of rupture recommended by Prof. Lanza, viz.:

Spruce and white pine.......................... 3000 lbs.

Oak... 4000 "

Yellow pine.................................... 5000 "

For oak increase values in table by $\frac{1}{3}$.   For yellow pine increase values in table by $\frac{2}{3}$.

The safe load for any other values per square inch is found by increasing or decreasing the loads given in the table in the same proportion as the increased or decreased fibre stress.

Span in Feet.	Depth of Beam.										
	6 Ins.	7 Ins.	8 Ins.	9 Ins.	10 Ins.	11 Ins.	12 Ins.	13 Ins.	14 Ins.	15 Ins.	16 Ins.
5	600	820	1070	1350	1670	2020	2400	2820	3270	3750	4270
6	500	680	890	1120	1390	1680	2000	2350	2730	3120	3560
7	430	580	760	960	1190	1440	1710	2010	2330	2680	3050
8	380	510	670	840	1040	1260	1500	1760	2040	2340	2670
9	330	460	590	750	930	1120	1330	1560	1810	2080	2370
10	300	410	530	670	830	1010	1200	1410	1630	1880	2130
11	270	370	490	610	760	920	1090	1280	1490	1710	1940
12	250	340	440	560	690	840	1000	1180	1360	1560	1780
13	230	310	410	520	640	780	930	1080	1260	1440	1640
14	210	290	380	480	590	720	860	1010	1170	1340	1530
15	200	270	360	450	560	670	800	940	1090	1250	1420
16	190	260	330	420	520	630	750	880	1020	1180	1330
17	180	240	310	400	490	590	710	830	960	1100	1260
18	170	230	290	370	460	560	670	780	910	1040	1190
19	160	210	280	360	440	530	630	740	860	990	1130
20	150	200	270	340	420	510	600	710	820	940	1070
21	140	190	260	320	390	480	570	670	780	890	1020
22	140	190	240	310	380	460	540	640	740	850	970
23	130	180	230	290	360	440	520	610	710	810	920
24	130	170	220	280	350	420	500	590	680	780	890
25	120	160	210	270	330	410	480	560	660	750	860
26	110	160	210	260	320	390	460	540	630	720	820
27	110	150	200	250	310	370	440	520	610	690	790
28	110	140	190	240	300	360	430	500	580	670	760
29	110	140	180	230	290	350	410	490	560	640	740

To obtain the safe load for any thickness multiply values for 1 inch by thickness of beam.

To obtain the required thickness for any load divide by safe load for 1 inch.

STRENGTH, WEIGHT, ETC., OF VARIOUS WOODS.

Name.	Strength per Sq. In. in Lbs.		Moduli of Elasticity.	Relative Hardn'ss Shell-bark Hickory being 1000.	Weight per Cubic Foot.	Specific Gravity.
	Tensile.	Crushing in Direction of Grain.				
Acacia-wood. . . .	. . . .	. . . .	. . . .	. . . .	46.5	.750
Alder-wood.		6,150	. . . .	. . . .	50	.800
Apple-wood.	. . . .	. . . .	. . . .	700	49	.793
Ash (white). . . .	17,000	8,600	. . . .	775	40.77	.610
Ash (brown). . . .	11,000	. . . .	. . . .	. . . .	38.96	.623
Boxwood..	18,000	10,000	. . . .	. . . .	62	.990
Birch.	15,000	8,000	. . . .	630	35.44	.567
Beech.	11,500	9,000	. . . .	660	40.42	.650
Butternut.	9,000	6,000	. . . .	440	23.50	.376
Cherry.	. . . .	. . . .	. . . .	550	44.70	.715
Chestnut.	10,500	5,000	1,000,000	520	41.25	.660
Cork.					15	.240
Cedar (white). .	11,400	6,500	700,000	540	37.25	.596
Cedar (red). . . .	9,000	6,000	. . . .	. . . .	35	.560
Cypress.	5,000	6,000	900,000	. . . .	27.60	.441
Dogwood.	. . . .	. . . .	. . . .	750	47.25	.750
Ebony.	. . . .	. . . .	. . . .	. . . .	86.16	1.331
Elm.	13,000	8,000	. . . .	580	42	.671
Fir.	10,000	7,000	1,200,000	. . . .	32	.512
Gum.	17,000	7,000	. . . .	. . . .	52.69	.843
Hazel.	. . . .	. . . .	. . . .	720	53.75	.860
Holly.	. . . .	. . . .	. . . .	. . . .	47.50	.760
Hickory (pignut)	15,000	9,000	. . . .	950	49.50	.792
Hickory (shell-bark).	18,000	10,000	. . . .	1000	43.12	.690
Hemlock.	8,740	5,400	900,000	. . . .	23.00	.368
Hackmatack....	. . . .	. . . .	. . . .	. . . .	37.00	.592
Juniper	. . . .	. . . .	. . . .	. . . .	35.37	.566
Lancewood. . . .	. . . .	. . . .	. . . .	. . . .	45	.720
Larch.	9,500	. . . .	. . . .	. . . .	34.55	.552
Lignum-vitæ. . .	12,000	9,000	. . . .	. . . .	83.31	1.333
Logwood.	. . . .	. . . .	. . . .	. . . .	57.06	.913
Locust.	20,000	11,720	. . . .	. . . .	45.50	.728
Mahogany	12,000	6,000	. . . .	. . . .	55.75	.829
Maple (hard). . .	10,000	9,000	. . . .	550	46.87	.750
Maple (white). .	10,000	7,000	. . . .	. . . .	36	.576
Oak (white). . . .	16,000	6,000	1,100,000	850	53.75	.860
Oak (red or black).	10,000	8,000	. . . .	700	40.75	.652
Pear.	9,800	. . . .	. . . .	. . . .	47	.752
Plum.	. . . .	. . . .	. . . .	. . . .	49.06	.785
Poplar.	7,000	5,000	. . . .	510	23.99	.383
Pine (white). . .	7,000	5,000	1,000,000	300	30	.480
Pine (Norway). .	8,300	7,000	1,200,000	. . . .	33.25	.532
Pine (yellow). . .	16,000	5,500	1,200,000	540	38.40	.612
Pine(yellow long-leaf).	20,000	9,000	1,700,000	. . . .	43.62	.698
Pine (Oregon). . .	13,800	7,000	1,400,000	. . . .	34	.544
Rosewood.	. . . .	. . . .	. . . .	. . . .	45.50	.728
Redwood (Cal.). .	8,000	2,500	7,00000	. . . .	26.23	.419
Satinwood.	. . . .	. . . .	. . . .	. . . .	55.31	.885
Spruce (white). .	14,000	6,500	1,200,000	. . . .	31.25	.500
Tamarack.	. . . .	. . . .	. . . .	. . . .	23.93	.383
Walnut.	10,000	8,000	. . . .	650	41.93	.671
Willow.	12,000	. . . .	. . . .	. . . .	33.40	.535

ULTIMATE STRENGTH OF HOLLOW ROUND AND HOLLOW RECTANGULAR CAST-IRON COLUMNS.

Ultimate strength in pounds per square inch:

Round Columns.			Rectangular Columns.		
Square Bearing.	Pin and Square.	Pin Bearing.	Square Bearing.	Pin and Square.	Pin Bearing.
$\dfrac{80000}{1+\dfrac{(12l)^2}{800d^2}}$	$\dfrac{80000}{1+\dfrac{3(12l)^2}{1600d^2}}$	$\dfrac{80000}{1+\dfrac{(12l)^2}{400d^2}}$	$\dfrac{80000}{1+\dfrac{3(12l)^2}{3200d^2}}$	$\dfrac{80000}{1+\dfrac{9(12l)^2}{6400d^2}}$	$\dfrac{80000}{1+\dfrac{3(12l)^2}{1600d^2}}$

l = length of column in feet;
d = external diameter or least side of rectangle in inches.

$\dfrac{l}{d}$	Round Columns. Ultimate Strength in Pounds per Square Inch.			Rectangular Columns. Ultimate Strength in Pounds per Square Inch.		
	Square Bearing.	Pin and Square.	Pin Bearing.	Square Bearing.	Pin and Square.	Pin Bearing.
1.0	67800	62990	58820	70480	66520	62990
1.1	65690	60300	55730	68790	64260	60300
1.2	63530	57600	52690	67000	61940	57600
1.3	61340	54930	49740	65140	59600	54960
1.4	59140	52310	46900	63260	57270	52320
1.5	56940	49770	44290	61350	54960	49760
1.6	54760	47300	41630	59450	52680	47300
1.7	52620	44940	39210	57550	50460	44960
1.8	50530	42670	36930	55670	48300	42670
1.9	48490	40510	34790	53800	46230	40510
2.0	46510	38460	32790	51940	44200	38460
2.1	44600	36520	30920	50160	42260	36520
2.2	42750	34680	29180	48400	40400	34680
2.3	40980	32940	27540	46670	38630	32950
2.4	39280	31310	26030	44990	36930	31310
2.5	37650	29770	24620	43390	35310	29760
2.6	36090	28320	23300	41820	33770	28320
2.7	34600	26950	22070	40320	32310	26950
2.8	33180	25670	20930	38870	30920	25670
2.9	31820	24460	19860	37470	29600	24460
3.0	30530	23320	18870	36120	28340	23320
3.1	29310	22250	17940	34830	27150	22250
3.2	28140	21250	17070	33580	26030	21250
3.3	27030	20300	16260	32390	24960	20300
3.4	25970	19410	15500	31240	23940	19410

SAFE LOADS IN TONS OF 2000 LBS. FOR HOLLOW ROUND CAST-IRON COLUMNS.

Outside Diameter, Inches.	Thickness of Metal.	Length of Columns in Feet.									Sectional Area, Inches.	Weight, Lbs. of Col. per Ft. of L'gth.
		8	10	12	14	16	18	20	22	24		
		Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons		
6	½	26.2	23.0	20.1	17.5	15.2	13.2	11.5	.....	.....	8.6	26.95
6	¾	37.5	33.0	28.8	25.0	21.7	18.9	16.5	.....	.....	12.4	38.59
6	⅞	42.7	37.6	32.8	28.5	24.7	21.5	18.8	.....	.....	14.1	43.96
6	1	47.6	41.9	36.5	31.8	27.6	24.0	21.0	.....	.....	15.7	49.01
6	1⅛	52.2	46.0	40.1	34.8	30.2	26.3	23.0	.....	.....	17.2	53.76
7	¾	47.7	43.1	38.5	34.3	30.4	26.9	23.9	21.2	18.9	14.7	45.96
7	1	61.1	55.2	49.3	43.8	38.9	34.4	30.6	27.1	24.2	18.9	58.90
7	1⅛	67.2	60.8	54.3	48.3	42.8	37.9	33.7	29.9	26.7	20.8	64.77
8	¾	57.9	53.3	48.6	44.1	39.7	35.8	32.2	28.9	26.1	17.1	53.29
8	1	74.6	68.7	62.5	56.7	51.1	46.0	41.4	37.3	33.6	22.0	68.64
8	1⅛	89.9	82.8	75.5	68.4	61.7	55.5	49.9	44.9	40.5	26.5	82.71
9	¾	68.1	63.6	58.9	54.2	49.6	45.2	41.2	37.5	34.1	19.4	60.65
9	1	88.0	82.3	76.2	70.0	64.1	58.4	53.2	48.4	44.1	25.1	78.40
9	1⅛	106.6	99.6	92.2	84.8	77.6	70.8	64.4	58.7	53.4	30.4	94.94
9	1¼	123.8	115.7	107.1	98.5	90.1	82.2	74.8	68.1	62.0	35.3	110.26
9	1½	139.6	130.5	120.8	111.1	101.6	92.7	84.4	76.8	69.9	39.9	124.36
10	1	101.4	95.9	89.8	83.6	77.4	71.5	65.8	60.5	55.5	28.3	88.23
10	1¼	123.3	116.5	109.1	101.6	94.1	86.8	79.9	73.4	67.5	34.4	107.23
10	1½	143.7	135.8	127.3	118.5	109.7	101.2	93.2	85.6	78.7	40.1	124.99
10	1¾	162.7	153.8	144.1	134.1	124.2	114.6	105.5	97.0	89.1	45.4	141.65
11	1	114.8	109.4	103.5	97.3	91.0	84.8	80.2	73.1	67.7	31.4	98.03
11	1¼	139.9	133.3	126.1	118.6	110.9	103.3	97.8	89.4	82.5	38.3	119.46
11	1½	163.5	155.9	147.5	138.6	128.7	120.8	114.3	104.1	96.4	44.8	139.68
11	1¾	185.7	177.1	167.5	157.5	147.3	137.2	129.8	118.3	109.5	50.9	158.68
11	2	206.6	196.9	186.3	175.1	163.8	152.6	144.4	131.5	121.8	56.6	176.44
12	1	128.0	122.9	117.2	111.0	104.7	98.4	92.2	86.1	80.4	34.6	107.51
12	1¼	156.4	150.1	143.1	135.7	127.9	120.2	112.6	105.2	98.2	42.2	131.41
12	1½	183.3	175.9	167.7	159.0	149.9	140.9	132.0	123.3	115.1	49.5	154.10
12	1¾	208.7	200.4	191.0	181.1	170.7	160.4	150.3	140.5	131.1	56.4	175.53
12	2	232.7	223.4	213.0	201.9	190.4	178.9	167.6	156.6	146.1	62.8	195.75
13	1	141.2	136.3	130.7	124.7	118.5	112.1	105.8	99.5	93.5	37.7	117.53
13	1¼	172.8	166.8	160.0	152.7	145.0	137.2	129.4	121.8	114.4	46.1	143.86
13	1½	203.0	195.9	187.9	179.3	170.3	161.1	152.0	143.1	134.3	54.2	168.98
13	1¾	231.6	223.6	214.5	204.7	194.4	183.9	173.5	163.3	153.3	61.9	192.88
13	2	258.9	249.9	239.7	228.7	217.3	205.5	193.9	182.5	171.3	69.1	215.56
14	1	154.3	149.6	144.3	138.5	132.3	125.9	119.5	113.1	106.8	40.8	127.60
14	1¼	189.2	183.4	176.9	169.7	162.2	154.4	146.5	138.6	131.0	50.1	156.31
14	1½	222.6	215.8	208.1	199.7	190.8	181.7	172.3	163.1	154.1	58.9	183.67
14	1¾	254.4	246.7	237.9	228.3	218.1	207.6	197.0	186.5	176.2	67.4	210.00
14	2	284.8	276.2	266.4	255.6	244.2	232.4	220.6	208.8	197.2	75.4	235.12
15	1	167.4	162.9	157.8	152.1	146.0	139.7	133.3	126.8	120.4	44.0	137.28
15	1¼	205.5	200.0	193.7	186.7	179.3	171.5	163.6	155.7	147.9	54.0	168.48
15	1½	242.1	235.7	228.2	220.0	211.2	202.1	192.8	183.5	174.2	63.6	198.74
15	1¾	277.2	269.8	261.3	251.9	241.9	231.4	220.7	210.1	199.5	72.9	227.45
15	2	310.8	302.5	293.0	282.5	271.2	259.5	247.5	235.5	223.6	81.7	254.90

If all cast-iron or other hollow columns are filled with concrete after being set it adds to their strength and affords protection from rust and fire.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR STANDARD AND SPECIAL I BEAMS.

In Tons of 2000 Lbs.

Distance between Supports in Feet.	24″ I. 80 Lbs.	Add for Every Lb. Increase in Weight.	20″ I. 80 Lbs.	65 Lbs.	Add for Every Lb. Increase in Weight.	18″ I. 55 Lbs.	Add for Every Lb. Increase in Weight.	15″ I. 80 Lbs.	60 Lbs.	42 Lbs.	Add for Every Lb. Increase in Weight.
12	77.33	.53	65.18	51.98	.44	39.29	.39	47.14	36.09	26.18	.33
13	71.38	.48	60.16	47.98	.40	36.27	.36	43.51	33.31	24.17	.30
14	66.28	.45	55.87	44.56	.37	33.68	.34	40.40	30.93	22.44	.28
15	61.86	.42	52.14	41.59	.35	31.43	.31	37.71	28.87	20.94	.26
16	58.00	.39	48.88	38.99	.33	29.47	.29	35.35	27.07	19.63	.24
17	54.58	.37	46.01	36.69	.31	27.74	.28	33.27	25.47	18.48	.23
18	51.56	.35	43.45	34.66	.29	26.19	.26	31.42	24.06	17.45	.22
19	48.84	.33	41.17	32.83	.28	24.82	.25	29.77	22.79	16.53	.21
20	46.40	.32	39.11	31.19	.26	23.58	.24	28.28	21.65	15.71	.20
21	44.19	.30	37.24	29.70	.25	22.45	.22	26.94	20.62	14.96	.19
22	42.18	.29	35.55	28.35	.24	21.43	.21	25.71	19.68	14.28	.18
23	40.35	.27	34.01	27.12	.23	20.50	.20	24.59	18.83	13.66	.17
24	38.67	.26	32.59	25.99	.22	19.65	.20	23.57	18.04	03.19	.16
25	37.12	.25	31.29	24.95	.21	18.86	.19	22.63	17.32	12.57	.16
26	35.69	.24	30.08	23.99	.20	18.14	.18	21.76	16.66	12.08	.15
27	34.37	.23	28.97	23.10	.19	17.46	.17	20.95	16.04	11.64	.14
28	33.14	.23	27.93	22.28	.19	16.84	.17	20.20	15.47	11.22	.14
29	32.00	.22	26.97	21.51	.18	16.26	.16	19.51	14.93	10.83	.13
30	30.93	.21	26.07	20.79	.17	15.72	.16	18.86	14.43	10.47	.13
31	29.94	.20	25.23	20.12	.17	15.21	.15	18.25	13.97	10.13	.13
32	29.00	.20	24.44	19.49	.16	14.73	.15	17.68	13.53	9.82	.12
33	28.12	.19	23.70	18.90	.16	14.29	.14	17.14	13.12	9.52	.12
34	27.29	.19	23.00	18.35	.15	13.87	.14	16.64	12.74	9.24	.11
35	26.51	.18	22.35	17.82	.15	13.47	.13	16.16	12.37	8.98	.11
36	25.78	.18	21.73	17.33	.15	13.10	.13	15.71	12.03	8.73	.11

Safe loads given include weight of beam.   Maximum fibre stress, 16,000 lbs. per square inch.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR STANDARD AND SPECIAL I BEAMS.

In Tons of 2000 Lbs.

Distance between Supports in Feet.	12″ I. 40 Lbs.	12″ I. 31.5 Lbs.	Add for Every Lb. Increase in Weight.	10″ I. 25 Lbs.	Add for Every Lb. Increase in Weight.	9″ I. 21 Lbs.	Add for Every Lb. Increase in Weight.	Distance between Supports in Feet.	8″ I. 18 Lbs.	Add for Every Lb. Increase in Weight.
12	19.92	15.99	.26	10.85	.22	8.39	.20	5	15.17	.42
13	18.39	14.76	.24	10.02	.20	7.74	.18	6	12.64	.35
14	17.08	13.70	.23	9.30	.19	7.19	.17	7	10.84	.30
15	15.94	12.79	.21	8.68	.17	6.71	.16	8	9.48	.26
16	14.94	11.99	.20	8.14	.16	6.29	.15	9	8.43	.23
17	14.06	11.29	.19	7.66	.15	5.92	.14	10	7.59	.21
18	13.28	10.66	.18	7.24	.14	5.59	.13	11	6.90	.19
19	12.58	10.10	.17	6.86	.14	5.30	.12	12	6.32	.18
20	11.95	9.59	.16	6.51	.13	5.03	.12	13	5.83	.16
21	11.38	9.14	.15	6.20	.12	4.79	.11	14	5.42	.15
22	10.87	8.72	.14	5.92	.12	4.58	.11	15	5.06	.14
23	10.39	8.34	.14	5.66	.11	4.38	.10	16	4.74	.13
24	9.96	7.99	.13	5.43	.11	4.19	.10	17	4.46	.12
25	9.56	7.67	.13	5.21	.10	4.03	.09	18	4.21	.12
26	9.19	7.38	.12	5.01	.10	3.87	.09	19	3.99	.11
27	8.85	7.11	.12	4.82	.10	3.73	.09	20	3.79	.11
28	8.54	6.85	.11	4.65	.09	3.59	.08	21	3.61	.10
29	8.24	6.62	.11	4.49	.09	3.47	.08	....	......	....
30	7.97	6.40	.11	4.34	.09	3.36	.08	....	......	....

Safe loads given include weight of beam.   Maximum fibre stress, 16,000 lbs. per square inch.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR STANDARD AND SPECIAL I BEAMS.

In Tons of 2000 Lbs.

Distance between Supports in Feet	7" I. 15 lbs.	Add for Every Lb. Increase in Weight.	6" I. 12.25 lbs.	Add for Every Lb. Increase in Weight.	5" I. 9.75 lbs.	Add for Every Lb. Increase in Weight.	4" I. 7.5 lbs.	Add for Every Lb. Increase in Weight.	3" I. 5.5 lbs.	Add for Every Lb. Increase in Weight.
5	11.04	.36	7.75	.31	5.16	.26	3.18	.21	1.76	.16
6	9.20	.30	6.46	.26	4.30	.22	2.65	.18	1.47	.13
7	7.89	.26	5.54	.22	3.69	.19	2.27	.15	1.26	.11
8	6.90	.23	4.84	.19	3.23	.16	1.99	.13	1.10	.10
9	6.13	.20	4.31	.17	2.87	.14	1.77	.12	0.98	.09
10	5.52	.18	3.88	.16	2.58	.13	1.59	.11	0.88	.08
11	5.02	.16	3.52	.14	2.35	.12	1.45	.10	0.80	.07
12	4.60	.15	3.23	.13	2.15	.11	1.33	.09	0.73	.07
13	4.25	.14	2.98	.12	1.98	.10	1.22	.08	0.68	.06
14	3.94	.13	2.77	.11	1.84	.09	1.14	.08	0.63	.06
15	3.68	.12	2.58	.10	1.72	.09	1.06	.07	0.59	.05
16	3.45	.11	2.42	.10	1.61	.08	0.99	.07	0.55	.05
17	3.25	.11	2.28	.09	1.52	.08	0.94	.06	0.52	.05
18	3.07	.10	2.15	.09	1.43	.07	0.88	.06	0.49	.04
19	2.91	.09	2.04	.08	1.36	.07	0.84	.06	0.46	.04
20	2.76	.09	1.94	.08	1.29	.07	0.80	.05	0.44	.04
21	2.63	.09	1.85	.07	1.23	.06	0.76	.05	0.42	.04

Safe loads given include weight of beam. Maximum fibre stress, 16,000 lbs. per square inch.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR STANDARD AND SPECIAL CHANNELS.

In Tons of 2000 Lbs.

Distance between Supports in Feet.	15″ ⊏ 33 lbs.	Add for Every Lb. Increase in Weight.	12″ ⊏ 20.5 lbs.	Add for Every Lb. Increase in Weight.	10″ ⊏ 15 lbs.	Add for Every Lb. Increase in Weight.	9″ ⊏ 13.25 lbs.	Add for Every Lb. Increase in Weight.
10	22.23	.39	11.39	.32	7.14	.26	5.61	.24
11	20.20	.35	10.35	.29	6.49	.24	5.10	.21
12	18.52	.33	9.49	.26	5.95	.22	4.68	.20
13	17.10	.30	8.76	.24	5.49	.20	4.32	.18
14	15.87	.28	8.14	.23	5.10	.19	4.01	.17
15	14.82	.26	7.59	.21	4.76	.17	3.74	.16
16	13.89	.24	7.12	.20	4.46	.16	3.51	.15
17	13.07	.23	6.70	.18	4.20	.15	3.30	.14
18	12.35	.22	6.33	.18	3.96	.14	3.12	.13
19	11.70	.21	5.99	.17	3.76	.14	2.95	.12
20	11.11	.20	5.70	.16	3.57	.13	2.81	.12
21	10.58	.19	5.42	.15	3.40	.12	2.67	.11
22	10.10	.18	5.18	.14	3.24	.12	2.55	.11
23	9.66	.17	4.95	.14	3.10	.11	2.44	.10
24	9.26	.16	4.75	.13	2.97	.11	2.34	.10
25	8.89	.16	4.56	.13	2.85	.10	2.24	.09
26	8.55	.15	4.38	.12	2.74	.10	2.16	.09
27	8.23	.14	4.22	.12	2.64	.10	2.08	.09
28	7.94	.14	4.07	.11	2.55	.09	2.00	.08
29	7.66	.13	3.93	.11	2.46	.09	1.93	.08
30	7.41	.13	3.80	.11	2.38	.09	1.87	.08

Safe loads given include weight of channel.   Maximum fibre stress, 16,000 lbs. per square inch.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR STANDARD AND SPECIAL CHANNELS.

In Tons of 2000 Lbs.

Distance between Supports in Feet	8″ □ 11.25 Lbs.	Add for Every Lb. Increase in Weight.	7″ □ 9.75 Lbs.	Add for Every Lb. Increase in Weight.	6″ □ 8 Lbs.	Add for Every Lb. Increase in Weight.	5″ □ 6.5 Lbs.	Add for Every Lb. Increase in Weight.	4″ □ 5.25 Lbs.	Add for Every Lb. Increase in Weight.	3″ □ 4 Lbs.	Add for Every Lb. Increase in Weight.
5	8.61	.42	6.68	.36	4.62	.31	3.16	.26	2.02	.21	1.16	.16
6	7.18	.35	5.57	.30	3.85	.26	2.63	.22	1.68	.18	.97	.13
7	6.15	.30	4.77	.26	3.30	.22	2.26	.19	1.44	.15	.83	.11
8	5.38	.26	4.18	.23	2.89	.19	1.98	.16	1.26	.13	.73	.10
9	4.78	.23	3.71	.20	2.57	.17	1.76	.14	1.12	.12	.64	.09
10	4.31	.21	3.34	.18	2.31	.16	1.58	.13	1.01	.11	.58	.08
11	3.91	.19	3.04	.16	2.10	.14	1.44	.12	.92	.10	.53	.07
12	3.59	.18	2.78	.15	1.93	.13	1.32	.11	.84	.09	.48	.07
13	3.31	.16	2.57	.14	1.78	.12	1.22	.10	.78	.08	.45	.06
14	3.08	.15	2.39	.13	1.65	.11	1.13	.09	.72	.08	.41	.06
15	2.87	.14	2.23	.12	1.54	.10	1.05	.09	.67	.07	.39	.05
16	2.69	.13	2.09	.11	1.44	.10	.99	.08	.63	.07	.36	.05
17	2.53	.12	1.96	.11	1.36	.09	.93	.08	.59	.06	.34	.05
18	2.39	.11	1.86	.10	1.28	.09	.88	.07	.56	.06	.32	.04
19	2.27	.11	1.76	.09	1.22	.08	.83	.07	.53	.06	.31	.04
20	2.15	.11	1.67	.09	1.16	.08	.79	.07	.51	.05	.29	.04
21	2.05	.10	1.59	.09	1.10	.07	.75	.06	.48	.05	.28	.04
22	1.96	.10	1.52	.08	1.05	.07	.72	.06	.46	.05	.26	.04
23	1.87	.09	1.45	.08	1.00	.07	.69	.06	.44	.05	.25	.03
24	1.79	.09	1.39	.08	.96	.06	.66	.05	.42	.04	.24	.03
25	1.72	.08	1.34	.07	.92	.06	.63	.05	.40	.04	.23	.03

Safe loads given include weight of channel.   Maximum fibre stress, 16,000 lbs. per square inch.

WEIGHT, STRENGTH, ETC., OF STANDARD HOISTING ROPE

Composed of Six Strands and a Hemp Centre, Nineteen Wires to the Strand

Swedish Iron.

Trade Number.	Diameter in Inches.	Approximate Circumference in Inches.	Weight per Foot in Pounds.	Approximate Breaking Strain in Tons of 2000 Pounds.	Allowable Working Strain in Tons of 2000 Pounds.	Minimum Size of Drum or Sheave in Feet.
..	2¾	8½	11.95	114	22.8	16
	2½	7¾	9.85	95	18.9	15
1	2¼	7¼	8.00	78	15.60	13
2	2	6¼	6.30	62	12.40	12
3	1¾	5½	4.85	48	9.60	10
4	1⅝	5	4.15	42	8.40	8½
5	1½	4¾	3.55	36	7.20	7½
5½	1⅜	4¼	3.00	31	6.20	7
6	1¼	4	2.45	25	5.00	6½
7	1⅛	3½	2.00	21	4.20	6
8	1	3	1.58	17	3.40	5½
9	⅞	2¾	1.20	13	2.60	4½
10	¾	2¼	0.89	9.7	1.94	4
10¼	⅝	2	0.62	6.8	1.36	3½
10½	9/16	1¾	0.50	5.5	1.10	2¾
10¾	½	1½	0.39	4.4	0.88	2½
10a	7/16	1¼	0.30	3.4	0.68	2
10b	⅜	1⅛	0.22	2.5	0.50	1½
10c	5/16	1	0.15	1.7	0.34	1
10d	¼	¾	0.10	1.2	0.24	¾

Cast Steel.

Trade Number.	Diameter in Inches.	Approximate Circumference in Inches.	Weight per Foot in Pounds.	Approximate Breaking Strain in Tons of 2000 Pounds.	Allowable Working Strain in Tons of 2000 Pounds.	Minimum Size of Drum or Sheave in Feet.
..	2¾	8½	11.95	223	45.6	10
	2½	7¾	9.85	190	37.9	9½
1	2¼	7¼	8.00	156	31.2	8½
2	2	6¼	6.30	124	24.8	8
3	1¾	5½	4.85	96	19.2	7½
4	1⅝	5	4.15	84	16.8	6½
5	1½	4¾	3.55	72	14.4	5¾
5½	1⅜	4¼	3.00	62	12.4	5¼
6	1¼	4	2.45	50	10.0	5
7	1⅛	3½	2.00	42	8.40	4½
8	1	3	1.58	34	6.80	4
9	⅞	2¾	1.20	26	5.20	3½
10	¾	2¼	0.89	19.4	3.88	3
10¼	⅝	2	0.62	13.6	2.72	2½
10½	9/16	1¾	0.50	11.0	2.20	1¾
10¾	½	1½	0.39	8.8	1.76	1½
10a	7/16	1¼	0.30	6.8	1.36	1¼
10b	⅜	1⅛	0.22	5.0	1.00	1
10c	5/16	1	0.15	3.4	0.68	¾
10d	¼	¾	0.10	2.4	0.48	½

WEIGHT, STRENGTH, ETC., OF EXTRA STRONG CRUCIBLE CAST-STEEL ROPE.

Composed of Six Strands and a Hemp Centre, Nineteen Wires to the Strand.

Trade Number.	Diameter in Inches.	Approximate Circumference in Inches.	Weight per Foot in Pounds.	Approximate Breaking Strain in Tons of 2000 Pounds.	Allowable Working Strain in Tons of 2000 Pounds.	Minimum Size of Drum or Sheave in Feet.
..	2¾	8⅝	11.95	266	53	10
1	2½	7¾	9.85	222	45	9½
1	2¼	7¼	8.00	182	36.4	8½
2	2	6¼	6.30	144	28.8	8
3	1¾	5½	4.85	112	22.4	7¼
4	1⅝	5	4.15	97	19.4	6¼
5	1½	4¾	3.55	84	16.8	5¾
5½	1⅜	4¼	3.00	72	14.4	5½
6	1¼	4	2.45	58	11.6	5
7	1⅛	3½	2.00	49	9.80	4½
8	1	3	1.58	39	7.80	4
9	⅞	2¾	1.20	30	6.00	3½
10	¾	2⅜	0.89	22	4.40	3
10¼	⅝	2	0.62	15.8	3.16	2½
10½	9/16	1¾	0.50	12.7	2.54	1¾
10¾	½	1½	0.39	10.1	2.02	1½
10a	7/16	1⅜	0.30	7.8	1.56	1¼
10b	⅜	1⅛	0.22	5.78	1.15	1
10c	5/16	1	0.15	4.05	0.81	¾
10d	¼	¾	0.10	2.70	0.54	½

Seven Wires to the Strand.

Trade Number.	Diameter in Inches.	Approximate Circumference in Inches.	Weight per Foot in Pounds.	Approximate Breaking Strain in Tons of 2000 Pounds.	Allowable Working Strain in Tons of 2000 Pounds.	Minimum Size of Drum or Sheave in Feet.
11	1½	4¾	3.55	79	15.8	8½
12	1⅜	4¼	3.00	68	13.6	8
13	1¼	4	2.45	56	11.2	7¼
14	1⅛	3½	2.00	46	9.20	6¼
15	1	3	1.58	37	7.40	5¾
16	⅞	2¾	1.20	23	5.60	5
17	¾	2¼	0.89	21	4.20	4½
18	11/16	2⅛	0.75	18.4	3.68	4
19	⅝	2	0.62	15.1	3.02	3½
20	9/16	1¾	0.50	12.3	2.46	3
21	½	1½	0.39	9.70	1.94	2½
22	7/16	1¼	0.30	7.50	1.50	2¼
23	⅜	1⅛	0.22	5.58	1.11	2
24	5/16	1	0.15	3.88	0.77	1¾
25	9/32	⅞	0.125	3.22	0.64	1½

WEIGHT, STRENGTH, ETC., OF COPPER, IRON, TINNED AND GALVANIZED SASH-CORDS.

Composed of Six Strands and a Cotton Centre, Seven Wires to the Strand.

Trade Number.	Diameter in Inches.	Weight per Foot in Pounds.		Approximate Breaking Strain in Pounds.		
				Iron.		Bright Copper.
		Iron.	Copper.	Bright.	Annealed.	
26	¼	0.100	0.115	2200	1600	1265
27	3/32	0.076	0.087	1809	1254	1022
27½	1/16	0.056	0.064	1417	947	792
28	⅛	0.025	0.029	790	467	435
28½	3/32	0.014	0.016	510	280	272
29	1/16	0.006	0.007	262	132	140

APPROXIMATE WEIGHT AND STRENGTH OF MANILA ROPE.

Manila, Sisal, New Zealand, and Jute Ropes weigh (about) alike. Tarred Hemp Cordage will weigh (about) one-fourth more. Manila is about 25 per cent stronger than Sisal. Working load about one-fourth of breaking strain.

Circumference in Inches.	Diameter in Inches.	Weight of 1000 Feet in Pounds.	Number of Feet and Inches in One Pound.		Strength of New Manila Rope in Pounds.
			Ft.	Ins.	
¾	¼	23	50		450
1	5/16	33	33		780
1⅛	⅜	42	25		1,000
1¼	7/16	52	19		1,280
1½	½	74	11		1,760
1¾	9/16	101	9		2,400
2	⅝	132	7		3,140
2¼	¾	167	6		3,970
2½	13/16	207	5		4,900
2¾	⅞	250	4		5,900
3	1	297	3	6	7,000
3¼	1 1/16	349	2	10	8,200
3½	1⅛	405	2	4	9,600
3¾	1¼	465	2	1	11,000
4	1 5/16	529	1	10	12,500
4¼	1⅜	597	1	8	14,000
4½	1 7/16	669	1	5	15,800
4¾	1½	746	1	4	17,600
5	1⅝	826	1	2	19,500
5½	1¾	1000	1		23,700
6	1⅞	1190		10	28,000
6¼	2	1291		9½	33,000
6½	2¼	1397		8½	38,000
7	2¼	1620		7	44,000
7½	2⅜	1860		6½	50,000
8	2 9/16	2116		5½	60,000
8½	2¾	2388		5	63,000
9	2⅞	2673		4½	67,700
9½	3	2983		4	70,000
10	3 3/16	3306		3⅝	78,000

STRENGTH OF MATERIALS.

Ultimate resistance to tension, in pounds per square inch.

METALS AND ALLOYS.

	Average.
Aluminum bronze:	
10 per cent Al and 90 per cent copper............	85,000
1¼ " " " 98½ " "	28,000
Brass, cast...................................	18,000
Brass wire...................................	49,000
Bronze or gun metal...........................	36,000
Copper, cast..................................	19,000
Copper, sheet.................................	30,000
Copper, bolts.................................	36,000
Copper wire (unannealed).......................	60,000
Iron, cast, 13,400 to 29,000....................	16,500
Iron wire, black or annealed....................	56,000
Iron wire, bright, hard drawn.	78,400
Lead, sheet...................................	3,300
Steel .... 45,000 to 120,000	
Steel aluminum, 2⅛ per cent aluminum...........	70,000
Steel copper, 35 per cent copper................	60,000
Steel nickel, 3¼ per cent nickel.................	86,000
Steel cast, wire Bessemer......................	2,896,000
Steel cast, wire high carbon.	179,200
Steel cast, wire mild O. H......................	134,000

The modulus of elasticity of steel from recent tests is from 27,000,000 to 31,000,000. Average, 29,000,000.

Tin, cast....................................	4,600
Zinc.................................... 7,000 to 8,000	

STONE, NATURAL AND ARTIFICIAL.

Brick and cement.............................	280 to 300
Glass.......................................	2,560
Slate................................... 2,400 to 4,600	
Mortar, ordinary lime.........................	10 to 20

ULTIMATE RESISTANCE TO COMPRESSION.
Metals.

Brass, cast..................................	10,300
Iron, " .... 85,000 to 125,000	
Steel....................... 45,000 to 120,000	

STONE, NATURAL AND ARTIFICIAL.

		Average.
Brick, weak		550 to 800
" strong		1,100
" fire		1,700
Brickwork, ordinary, in cement		300 to 600
" best		1,000
Glass		30,000
Granite		5,000 to 18,000
Limestone		4,000 to 16,000
Marble		4,000 to 18,000
Sandstone, ordinary		2,500 to 10,000

ULTIMATE RESISTANCE TO SHEARING.

Metals.

Iron, cast	25,000
Steel	50,000

MODULI OF ELASTICITY.

Metals.

Iron (cast)	12,000,000
Iron (wrought shapes)	27,000,000
Iron (rerolled bars)	26,000,000
Steel (casting)	30,000,000
Steel (structural)	29,000,000

COMPRESSIVE STRENGTH OF PORTLAND-CEMENT MORTAR IN POUNDS PER SQUARE INCH.

Age in			Neat.	1 Cement, 1 Sand.	1 Cement, 2 Sand.	1 Cement, 3 Sand.	1 Cement, 4 Sand.
Air.	Water.	Air.					
7	....	....	4970	2850	1370	....	473
1	6	....	6260	2880	1440	....	557
30	....	....	6140	3400	1490	....	656
1	29	....	8870	4680	2750	....	950
92	....	....	6080	3410	....	....	....
1	91	....	9560	....	....	....	....
1	91	2	....	7570	....	....	....
1	90	2	....	....	4990	....	....
93	....	....	....	....	2635	....	....
100	....	....	....	....	....	....	1030
101	....	....	....	....	....	1510	....
1	96	4	....	....	....	3140	....
1	95	4	....	....	....	....	1970
1	70	....	....	....	....	2570	....

WORKING STRENGTH OF VARIOUS BUILDING MATERIALS *

COMPRESSION (DIRECT).

STEEL AND IRON.

The safe carrying capacity of various building materials (except in case of columns) are as follows; the strength given being the working strength in pounds per square inch of section.

Rolled steel...	16,000
Cast steel...	16,000
Wrought iron..	12,000
Cast iron (in short blocks)............................	16,000
Steel ribs and rivets (bearing)........................	20,000
Wrought-iron pins and rivets (bearing)................	15,000

TIMBER.

	With Grain.	Across Grain
Oak...........................	900	800
Yellow pine....................	1000	600
White pine.....................	800	400
Spruce.........................	800	400
Locust.........................	1200	1000
Chestnut.......................	500	1000
Hemlock........................	500	500

CONCRETE.

Concrete (Portland) cement, 1; sand, 2; stone, 4.......	230
Concrete (Portland) cement, 1; sand, 2; stone, 5.......	208
Concrete (Rosendale), or equal, cement, 1; sand, 2; stone, 4–125	
Concrete (Rosendale, or equal) cement, 1; sand, 2; stone, 5–111	

STONEWORK

Rubble stonework in Portland cement-mortar...........	140
Rubble stonework in Rosendale cement-mortar..........	111
Rubble stonework in lime- and cement-mortar..........	97
Rubble stonework in lime-mortar	70

BRICKWORK.

Brickwork in Portland cement-mortar; cement, 1; sand, 3	250
Brickwork in Rosendale, or equal, cement-mortar. cement, 1; sand. 3.......	208
Brickwork in lime- and cement-mortar; cement, 1; lime, 1; sand, 6.	160
Brickwork in lime-mortar; lime, 1; sand, 4.	111

* The stresses given in these tables are those recommended by the National Board of Fire Underwriters.

GRANITES, STONE, ETC.

Granites (according to test)	1000 to 2400
Gneiss stone	1200
Limestones (according to test)	700 to 2300
Marbles (according to test)	600 to 1200
Sandstones (according to test)	400 to 1600
Bluestone	2000
Brick (hard-burned, flatwise)	300
Slate	1000

SAFE EXTREME FIBRE STRESS (BENDING) OF VARIOUS MATERIALS IN POUNDS PER SQUARE INCH OF SECTION.

Rolled-steel beams	16,000
Rolled-steel pins, rivets, and bolts	20,000
Riveted-steel beams (net flange section)	14,000
Rolled wrought-iron beams	12,000
Rolled wrought-iron pins, rivets, and bolts	15,000
Riveted wrought-iron beams (net flange section)	12,000
Cast-iron compression side	16,000
Cast-iron tension side	3,000
Yellow pine	12,000
White pine	800
Spruce	800
Oak	1,000
Locust	12,000
Hemlock	600
Chestnut	800
Granite	180
Gneiss	150
Limestone	150
Slate	400
Marble	120
Sandstone	100
Bluestone	300
Concrete (Portland) cement, 1; sand, 2; stone, 4	30
Concrete (Portland) cement, 1; sand, 2; stone, 5	20
Concrete (Rosendale or equal) cement, 1; sand, 2; stone, 4	16
Concrete (Rosendale or equal) cement, 1; sand, 2; stone, 5	10
Brick (hard-burned)	50
Brickwork (in cement)	30

TENSILE WORKING STRENGTH OF VARIOUS MATERIALS IN
POUNDS PER SQUARE INCH OF SECTION.

Rolled steel	16,000
Cast steel	16,000
Wrought iron	12,000
Cast iron	3,000
Yellow pine	1,200
White pine	800
Spruce	800
Oak	1,000
Hemlock	600

SHEAR WORKING STRENGTH OF VARIOUS MATERIALS IN
POUNDS PER SQUARE INCH OF SECTION.

Steel web-plates	9,000
Steel shop-rivets and pins	10,000
Steel field-rivets	8,000
Steel field-bolts	7,000
Wrought-iron web-plates	6,000
Wrought-iron shop-rivets and pins	7,500
Wrought-iron field-rivets	6,000
Wrought-iron field-bolts	5,500
Cast iron	3,000

	With Fibre.	Across Fibre.
Yellow pine	70	500
White pine	40	250
Spruce	50	320
Oak	100	600
Locust	100	720
Hemlock	40	275
Chestnut	40	150

WORKING STRENGTH OF MASONRY.

The safe load for brickwork is

Eight tons per superficial foot when lime-mortar is used.

Eleven and one half tons per superficial foot when lime- and cement-mortar, mixed, are used.

Fifteen tons per superficial foot when cement-mortar is used

RUBBLE STONEWORK.

The safe load for rubble stonework is

Ten tons per superficial foot when Portland cement is used.

Eight tons per superficial foot when natural cement is used.

Seven tons per superficial foot when lime- and cement-mortar, mixed, are used.

Five tons per superficial foot when lime-mortar is used.

CONCRETE.

The safe load for concrete is

Fifteen tons per superficial foot when Portland cement is used.

Eight tons per superficial foot when natural cement is used.

The above strength is for concrete, mixed, 1–3–5.

WORKING STRENGTH OF COLUMNS IN POUNDS PER SQUARE INCH OF SECTION.

Recommended by the National Board of Fire Underwriters.

When the Length Divided by Least Radius of Gyration equals	Working Stress per Square Inch of Section.		
	Cast Iron.	Steel.	Wrought Iron.
120.	. . . .	8,240	4,400
110.	. . . .	8,820	5,200
100.	. . . .	9,400	6,000
90.	. . . .	9,980	6,800
80.	. . . .	10,560	7,600
70.	9,200	11,104	8,400
60.	9,500	11,720	9,200
50.	9,800	12,300	10,000
40.	10,100	12,880	10,800
30.	10,400	13,460	11,600
20.	10,700	14,040	12,400
10.	11,000	14,620	13,200

And in like proportion for intermediate ratios.

When the Length Divided by the Least Diameter equals	Working Stress per Square Inch of Section.		
	Long-leaf Yellow Pine.	White Pine, Norway Pine, Spruce.	Oak.
30.	460	350	390
25.	550	425	475
20.	640	500	560
15.	730	575	645
12	784	620	696
10.	820	650	730

And in like proportion for intermediate ratios. Five-eighth the values given for white pine shall also apply to chestnut and hemlock posts.

For locust posts use one and one-half the value given for white pine.

WORKING STRENGTH (COMPRESSION) OF MASONRY AS ALLOWED BY THE BUILDING CODES OF VARIOUS CITIES.

Material.	Working Stress in Pounds per Square Inch of Section.			
	New York, 1902.	Chicago, 1905.	Philadelphia, 1902.	Cleveland, 1904.
Rubble stonework in Portland-cement mortar.	140	....	139	139
Rubble stonework in Rosendale or equal cement mortar.	111	....	139	97½
Rubble stonework in lime and cement mortar.	97	....	111	69½
Rubble stonework in lime mortar.	70	....	69½	55½
Rubble stonework, coursed, well bonded in lime mortar.	....	....	....	83⅓
Rubble stonework, coursed, well bonded in lime and cement mortar.	....	....	....	97¼
Rubble stonework, coursed, well bonded in Rosendale or equal cement mortar.	....	....	....	125
Rubble stonework, coursed, well bonded in Portland-cement mortar.	....	....	....	152¾
Stone ashlar or blocks, with full beds in lime mortar.	....	....	....	125
Stone ashlar or blocks, with full beds in lime and cement mortar.	....	....	....	166⅔
Stone ashlar or blocks, with full beds in Rosendale or equal cement mortar.	....	....	....	208⅓
Stone ashlar or blocks, with full beds in Portland-cement mortar.	....	....	....	288
Dimension stones in cement mortar.	....	139		
Dimension stones, dressed beds, in cement mortar.	....	173½		
Granites (according to test).	1000–2400			
Greenwich stone.	1200			
Gneiss (New York City).	1300			
Limestone (according to test).	700–2300			
Marble (according to test).	600–1200			
Sandstone (according to test).	400–1600			
Bluestone (North River).	2000			
Slate.	1000			
Brickwork in Portland-cement mortar: cement, 1; sand, 3.	250	173½	208	
Brickwork in Rosendale cement or equal mortar: cement, 1; sand, 3.	208	125	208	
Brickwork in lime and cement mortar: cement, 1; lime, 1; sand, 6.	160	....	167	
Brickwork in lime mortar: lime, 1; sand, 4.	111	90	111	
Brick, common kiln run, in lime mortar.	....	....	....	83⅓
Brick, common kiln run, in lime and cement mortar.	....	....	....	111

WORKING STRENGTH (COMPRESSION) OF MASONRY—*Continued.*

Material.	Working Stress in Pounds per Square Inch of Section.			
	New York, 1902.	Chicago, 1905.	Philadelphia, 1902.	Cleveland, 1904.
Brick, common kiln run, in Rosendale or equal cement mortar...	....	....	....	139
Brick, common kiln run, in Portland-cement mortar........	....	....	....	180½
Brick, common selected hard, in lime mortar..............	....	....	....	111
Brick, common selected hard, in lime and cement mortar.....	....	....	....	139
Brick, common selected hard, in Rosendale or equal cement mortar....................	....	....	....	166⅔
Brick, common selected hard, in Portland-cement mortar......	....	....	....	202
Brick, hard, pressed, hydraulic, or vitrified shale or paving, in lime mortar................	....	....	....	139
Brick, hard, pressed, hydraulic, or vitrified shale or paving, in lime and cement mortar......	....	....	....	166⅔
Brick, hard, pressed, hydraulic, or vitrified shale or paving, in Rosendale or equal cement mortar....................	....	....	....	194½
Brick, hard, pressed, hydraulic, or vitrified shale or paving, in Portland-cement mortar......	....	....	....	250

Note.—All brick acceptable under the New York Building Code must be good, hard, well-burned brick.

STRENGTH OF BRICK PIERS.

The late F. E. Kidder made some tests of brick piers laid up with various mortars, which at the age of about five months gave the following ultimate strength per square inch of section of the pier before failure:

Lime mortar, 3 parts; Portland cement, 1 part ...... 3020 lbs.
Lime mortar, 3 parts; Newark and Rosendale cements,
     1 part.................................. 2552 "
Portland cement, 1 part; sand, 2 parts............. 2500 "
Newark and Rosendale cements, 1 part; sand, 2 parts. 2135 "
Lime mortar, 3 parts; Roman cement, 1 part........ 2030 "
Roman cement, 1 part; sand, 2 parts.............. 1927 "
Lime mortar................................... 1562 "

The piers began to fail by cracking longitudinally at about one-half the ultimate strength,

LENGTH, DIAMETER, ETC., OF SPIKES, NAILS, TACKS, ETC.

SPIKES AND NAILS.

Sizes.	Length, Inches.	Standard Steel Wire Nails. Common. Diameter, Inches.	Common. Number per Lb.	Finishing. Diameter, Inches.	Finishing. Number per Lb.	Steel Wire Spikes. Length, Inches.	Steel Wire Spikes. Diameter, Inches.	Steel Wire Spikes. Number per Lb.	Sizes.	Common Iron Nails. Length, Inches.	Common Iron Nails. Number per Lb.
2d	1	.0524	1060	.0453	1558	3	.1620	41	2d	1	800
3d	1¼	.0588	640	.0508	913	3½	.1819	30	3d	1¼	400
4d	1½	.0720	380	.0508	761	4	.2043	23	4d	1½	300
5d	1¾	.0764	275	.0571	500	4½	.2294	17	5d	1¾	200
6d	2	.0808	210	.0641	350	5	.2576	13	6d	2	150
7d	2¼	.0858	160	.0641	315	5½	.2893	11	7d	2¼	120
8d	2½	.0935	115	.0720	214	6	.2893	10	8d	2½	85
9d	2¾	.0963	93	.0720	195	6½	.2249	7½	9d	2¾	75
10d	3	.1082	77	.0808	137	7	.2249	7	10d	3	60
12d	3¼	.1144	60	.0808	127	8	.3648	5	12d	3¼	50
16d	3½	.1285	48	.0907	90	9	.3648	4½	16d	3½	40
20d	4	.1620	31	.1019	62	....	....	....	20d	4	20
30d	4½	.1819	22	....	....	....	....	....	30d	4½	16
40d	5	.2043	17	....	....	....	....	....	40d	5	14
50d	5½	.2294	13	....	....	....	....	....	50d	5½	11
60d	6	.2576	11	....	....	....	....	....	60d	6	8

TACKS.

Title, Ounce.	Length, Inches.	Number per Pound.	Title, Ounce.	Length, Inches.	Number per Pound.	Title, Ounce.	Length, Inches.	Number per Pound.
1	⅛	16,000	4	⁷⁄₁₆	4000	14	¹³⁄₁₆	1143
1½	³⁄₁₆	10,666	6	⁹⁄₁₆	2666	16	⅞	1000
2	¼	8,000	8	⅝	2000	18	¹⁵⁄₁₆	888
2½	⁵⁄₁₆	6,400	10	¹¹⁄₁₆	1600	20	1	800
3	⅜	5,333	12	¾	1333	22	1¹⁄₁₆	727
						24	1⅛	666

NUMBER AND DIAMETER OF WOOD SCREWS.

Number.	Diameter.	Number.	Diameter.	Number.	Diameter.	Number.	Diameter.
0	.056	8	.162	16	.268	24	.374
1	.069	9	.175	17	.281	25	.387
2	.082	10	.188	18	.293	26	.401
3	.096	11	.201	19	.308	27	.414
4	.109	12	.215	20	.321	28	.427
5	.122	13	.228	21	.334	29	.440
6	.135	14	.241	22	.347	30	.453
7	.149	15	.255	23	.361		

WROUGHT SPIKES.
Number to a keg of 150 pounds.

L'gth, Ins.	¼ In., Number.	⁵⁄₁₆ In., Number.	⅜ In., Number.	L'gth, Ins.	¼ In., Number.	⁵⁄₁₆ In., Number.	⅜ In., Number.	⁷⁄₁₆ In., Number.	½ In., Number.
3	2250	....	....	7	1161	662	482	445	306
3½	1890	1208	....	8	....	635	455	384	256
4	1650	1135	....	9	....	573	424	300	240
4½	1464	1064	....	10	....	....	391	270	222
5	1380	930	742	11	....	....	....	249	203
6	1292	868	570	12	....	....	....	236	180

WEIGHT OF COPPER NAILS.
Cut Copper Slating Nails.

1¼ inch, about 190 to the pound.
1½ inch, about 135 to the pound.

Cut Yellow Metal Slating Nails.

1¼ inch, about 154 to the pound.
1½ inch, about 140 to the pound.

Copper Wire Slating Nails.

⅞ inch No. 12 gauge about 303 per pound.
1   "   "   12   "   "   270   "   "
1¼   "   "   11   "   "   196   "   "
1½   "   "   10   "   "   134   "   "
1¼   "   "   12   "   "   231   "   "
1½   "   "   12   "   "   210   "   "

NUMBER OF BOAT SPIKES TO 200-POUND KEG.

Length, Inches.	Diameter.						
	¼ Inch Square.	⁵⁄₁₆ Inch Square.	⅜ Inch Square.	⁷⁄₁₆ Inch Square.	½ Inch Square.	⅝ Inch Square.	¾ Inch Square.
3	3300	....	....	....	....	....	....
3½	2880	....	....	....	....	....	....
4	2343	1671	....	....	....	....	....
4½	2200	1364	1039	....	....	....	....
5	2030	1308	935	....	....	....	....
5½	1828	1175	880	....	....	....	....
6	1624	1115	710	562	433	....	....
7	1420	988	665	516	400	....	....
8	1220	849	602	453	337	....	....
9	....	....	519	409	305	....	....
10	....	....	468	369	297	182	....
12	....	....	410	302	241	155	....
14	....	....	....	....	216	130	95
16	....	....	....	....	182	122	80

WEIGHT OF VARIOUS MATERIALS AS COMPARED WITH WATER WEIGHING 62.5 LBS.

Names of Substances.	Specific Gravity.	Names of Substances.	Specific Gravity.
Aluminum { cast.......	2.60	Mahogany...........	0.56–1.09
{ hammered.	2.75	Maple, dry...........	0.70
Amber............	1.08	Marble............	2.52–2.85
Anthracite..........	1.40–1.70	Masonry, stone, dry....	2.00–2.55
Asphaltum..........	1.10–1.20	" brick, " :..	1.50–1.60
Brass { cast..........	8.40–8.70	Mercury at 32° Fahr....	13.596
{ rolled..........	8.57	Mica............	2.80
Brick, common, hard...	1.53–2.30	Nickel...	8.8
Cement, ground, loose..	1.85	Oak, dry............	0.69–1.03
Charcoal............	0.44	Petroleum at 59° Fahr..	0.80
Cherry, dry..........	0.76–0.84	Pine...............	0.35–0.60
Clay, dry............	1.80–2.60	Platinum { cast........	21.15
Coal, bituminous.....	1.20–1.50	{ hammered..	21.3–21.5
Coke, loose..........	0.55	Quartz.............	2.5–2.80
Concrete............	2.47	Saltpetre, Chili........	2.26
Copper { cast........	8.79	" Kali........	1.95–2.08
{ rolled........	8.78–9.00	Sand, fine, dry........	1.40–1.65
Diamond............	3.52	" wet	1.90–2.05
Earth, humus........	1.30–1.80	" coarse.........	1.40–1.50
Glass, common window.	2.64	Sandstone..........	2.20–2.50
Gneiss, common......	2.40–2.70	Silver { cast........	10.48
Gold { cast, pure, or 24 carat.........	19.28	{ hammered.....	10.62
{ pure, hammered.	19.33	Slate..............	2.60–2.70
Granite	2.50–3.00	Snow, freshly fallen....	0.19
Gypsum, cast, dry.....	0.97	Steel...............	7.26–7.86
Hornblende..........	3.00	Sulphur............	1.93–2.07
Ice................	0.88–0.92	Sodium	0.978
Iron { cast.........	7.10–7.50	Tin { cast...........	7.20
{ wrought.......	7.79	{ rolled	7.30
Ivory..............	1.82	Water, pure rain or distilled, at 39° F......	1.00
Lead..............	11.37	Water, sea..........	1.03
Lime..............	2.30–3.20	Walnut, dry.........	0.60–0.81
Lime, slaked.........	1.30–1.40	Wax..............	0.95–0.98
Limestones..........	2.46–2.84	Zinc { cast...........	6.90
Magnesium..........	1.74	{ rolled..........	7.20

WEIGHT OF A CUBIC FOOT OF SUBSTANCES.

Names of Substances.	Average Weight, Pounds.
Aluminum....................................	162
Anthracite, solid, of Pennsylvania.....................	93
" broken, loose...........................	54
" " moderately shaken.................	58
" heaped bushel, loose......................	(80)
Ash, American, white, dry...........................	38
Asphaltum.......................................	87

WEIGHT OF A CUBIC FOOT OF SUBSTANCES—(*Continued*).

Names of Substances.	Average Weight, Pounds.
Brass (copper and zinc), cast	504
" rolled	524
Brick, best pressed	150
" common, hard	125
" soft, inferior	100
Brickwork, pressed brick	140
" ordinary	112
Cement, hydraulic, ground, loose, American Rosendale	56
" " " " " Louisville	50
" " " " English, Portland	90
Cherry, dry	42
Chestnut, dry	41
Clay, potters' dry	119
" in lump, loose	63
Coal, bituminous, solid	84
" " broken, loose	49
" " heaped bushel, loose	(74)
Coke, loose, of good coal	26.3
" " heaped bushel	(40)
Copper, cast	542
" rolled	548
Earth, common loam, dry, loose	76
" " " " moderately rammed	95
" as a soft, flowing mud	108
Ebony, dry	76
Elm, dry	35
Flint	162
Glass, common window	157
Gneiss, common	168
Gold, cast, pure, or 24 carat	1204
" pure, hammered	1217
Grain, at 60 lbs. per bushel	48
Granite	170
Gravel, about the same as sand, which see.	
Gypsum (plaster of Paris)	142
Hemlock, dry	25
Hickory, dry	53
Hornblende, black	203
Ice	58.7

WEIGHT OF A CUBIC FOOT OF SUBSTANCES—(*Continued*).

Names of Substances.	Average Weight, Pounds.
Iron, cast.	450
" wrought, purest.	485
" " average.	480
Ivory.	114
Lead.	711
Lignum vitæ, dry.	83
Lime, quick, ground, loose, or in small lumps.	53
" " " " thoroughly shaken.	75
" " " " per struck bushel.	66
Limestones and marbles.	168
" " " loose, in irregular fragments.	96
Magnesium	109
Mahogany, Spanish, dry.	53
" Honduras, dry.	35
Maple, dry.	45
Marbles, see Limestones.	
Masonry, of granite or limestone, well dressed.	165
" " mortar rubble.	154
" " dry " (well scabbled).	138
" " sandstone, well dressed.	144
Mercury, at 32° Fahrenheit.	849
Mica.	183
Mortar, hardened.	103
Mud, dry, close.	80 to 110
Mud, wet, fluid, maximum.	120
Oak, live, dry.	59
Oak, white, dry.	50
" other kinds.	32 to 45
Petroleum.	55
Pine, white, dry.	25
" yellow, Northern.	34
" " Southern.	45
Platinum.	1342
Quartz, common, pure.	165
Rosin.	69
Salt, coarse, Syracuse, N. Y.	45
" Liverpool, fine, for table use.	49
Sand, of pure quartz, dry, loose.	90 to 106
" well shaken.	99 to 117

WEIGHT OF A CUBIC FOOT OF SUBSTANCES—(*Continued*).

Names of Substances.	Average Weight, Pounds.
Sand, perfectly wet.	120 to 140
Sandstones, fit for building.	151
Shales, red or black.	162
Silver.	655
Slate.	175
Snow, freshly fallen.	5 to 12
" moistened and compacted by rain.	15 to 50
Spruce, dry.	25
Steel.	490
Sulphur.	125
Sycamore, dry.	37
Tar.	62
Tin, cast.	459
Turf or peat, dry, unpressed.	20 to 30
Walnut, black, dry.	38
Water, pure rain or distilled, at 60° Fahrenheit.	62⅓
" sea.	64
Wax, bees.	60.5
Zinc or spelter.	437.5

Green timbers usually weigh from one-fifth to one-half more than dry.

WEIGHT OF DIFFERENT MATERIALS.

	Pounds.
1 barrel of lime.	200 to 230
1 " " cement (hydraulic or Rosendale).	300
1 " " " (Portland).	400
1 " " " (Scotch, Roman)	350
1 " " fire-clay (American).	300
1 " " " (English).	350
1 " " brick-dust.	350
1 " " marble-dust.	350
1 " " plaster, California	260
1 " " " Wotherspoon (Eastern).	275
1 " " " (ground gypsum or land)	320

Fire-brick 6½ to 7 pounds each.

APPROXIMATE WEIGHT OF VARIOUS ROOF COVERINGS.

Material.	Weight in Pounds per Square of Roof.
Yellow pine (Northern) sheathing 1 inch thick.	300
" " (Southern).	400
Spruce.	200
Chestnut or maple.	400
Ash or oak.	500
Shingles, pine.	200
Slate $\frac{1}{4}$ inch thick.	900
Sheet iron $\frac{1}{16}$ inch thick.	300
" " $\frac{1}{16}$ inch " and laths.	500
Iron, corrugated.	100 to 375
" galvanized, flat.	100 to 350
Tin.	70 to 125
Felt and asphalt.	100
" " gravel.	800 to 1000
Skylights, glass, $\frac{3}{16}$ inch to $\frac{1}{2}$ inch thick.	250 to 700
Sheet lead.	500 to 800
Copper.	80 to 125
Zinc.	100 to 200
Tiles, flat.	1500 to 2000
" " with mortar.	2000 to 3000
" pan.	1000

ANGLES OF ROOFS AS COMMONLY USED.

Propor- tion of Rise to Span.	Angle.		Length of Rafter to Rise.	Propor- tion of Rise to Span.	Angle.		Length of Rafter to Rise.
	Deg.	Min.			Deg.	Min.	
$\frac{1}{1}$	45	..	1.4142	$\frac{1}{4}$	25	34	2.2361
$\frac{3}{4}$	33	41	1.8023	$\frac{1}{5}$	21	48	2.6926
$\frac{1}{2\sqrt{3}}$	30	..	2.0000	$\frac{1}{6}$	18	26	3.1623

APPROXIMATE LOADS PER SQUARE FOOT FOR ROOFS OF SPANS UNDER SEVENTY-FIVE FEET, INCLUDING WEIGHT OF TRUSS.

Roof covered with corrugated sheets, unboarded... 8 pounds.
"   "   "   "   " on boards.... 11 "
"   "   " slate, on laths. .... 13 "
Same, on boards $1\frac{1}{4}$ in. thick.................... 16 "
Roof covered with shingles, on laths............. 10 "
Add to above, if plastered below rafters. .... 10 "
Snow, light, weighs per cubic foot. .... 5 to 12 "

For spans over 75 feet add 4 pounds to the above loads per square foot.

It is customary to add 30 pounds per square foot to the above for snow and wind when separate calculations are not made.

PRESSURE OF WIND ON ROOFS. (Unwin.)

a = angle of surface of roof with direction of wind;

F = force of wind in pounds per square foot;

A = pressure normal to surface of roof = $F \sin a^{1.84 \cos a - 1}$

B = pressure perpendicular to direction of wind = $F \cot a \sin a^{1.84 \cos a}$.

C = pressure parallel to direction of wind = $F \sin a^{1.84 \cos a}$.

Angle of roof = a.	5°	10°	20°	30°	40°	50°	60°	70°	80°	90°
$A = F \times$	.125	.21	.45	.66	.83	.95	1.00	1.02	1.01	1.00
$B = F \times$	.122	.24	.42	.57	.64	.61	.50	.35	.17	.00
$C = F \times$	.01	.04	.15	.33	.53	.73	.85	.96	.99	1.00

RELATIVE WEIGHTS OF METALS.

Cubic inches multiplied by:
.263 = pounds of cast iron
.281 = "   " wrought iron
.283 = "   " steel
.3225 = "   " copper
.3037 = "   " brass
.26 = "   " zinc
.4103 = "   " lead
.2636 = "   " tin
.4908 = "   " mercury

Cylindrical inches multiplied by:
.2065 = pounds of cast iron
.2168 = "   " wrought iron
.2223 = "   " steel
.2533 = "   " copper
.2385 = "   " brass
.2042 = "   " zinc
.3223 = "   " lead
.207 = "   " tin
.3854 = "   " mercury

HEIGHT OF TALL BUILDINGS, TOWERS, SPIRES, ETC.

Eiffel Tower, France	985	feet
Tower of Babel	680	"
Singer Building, New York (proposed)	612	"
Washington Monument, Washington, D. C	555	"
City Hall, Philadelphia, Pa	537	"
Cologne Cathedral, Germany	512	"
Tower of Baalbec	500	"
Rouen Cathedral, France	495	"
Pyramid of Cheops, Egypt	486	"
Antwerp Cathedral, Belgium	476	"
Church of St. Nicholas, Hamburg	473	"
Pyramid of Cephrenes, Egypt	473	"
Strasburg Cathedral, Germany	468	"
St. Martin's, Landshut, Germany	462	"
Vienna Cathedral, Austria	449	"
St. Peter's Church, Rome	448	"
St. Stephen's, Vienna	446	"
Cathedral at Amiens	422	"
St. Mary's, Lubeck, Germany	413	"
Salisbury Cathedral	404	"
Antwerp Cathedral, Belgium	402	"
Palace of Justice, Brussels, Belgium	400	"
Cremona Cathedral	392	"
Park Row Building, New York	392	"
St Peter's, Rome	391	"
Cathedral at Florence, Italy	386	"
Church at Fribourg, Germany	386	"
City Hall, Brussels	370	"
St. Paul's, London	365	"
Cathedral of St. Petersburg	363	"
Times Building, New York	363	"
Cathedral of Seville, Spain	360	"
International Banking Company's Building, New York	352	"
Cathedral of Utrecht, Holland	356	"
Pyramid of Sakkarah, Egypt	356	"
Cathedral of Milan, Lombardy	355	"
Manhattan Life Insurance Building, New York	348	"
Wall St. Exchange Building, N. Y	340	"
Victoria's Tower, House of Parliament, London	340	"

Madison Square Garden Tower, New York.	332	feet
St. Mark's Church, Venice, Italy.	328	"
St. Paul Building, New York.	317	"
Land & Title Building, Philadelphia.	317	"
Court House, Pittsburg Pa.	319	"
Duomo, or Sta. Maria del Fiore, at Florence.	310	"
Pulitzer Building, New York.	309	"
American Surety Building, New York.	308	"
American Tract Society Building, New York.	306	"
Statue of Liberty, New York Harbor.	305	"
Masonic Temple, Chicago, Ill.	303	"
Lincoln Cathedral, England.	300	"
"Flatiron" Building, New York.	293	"
Empire Building, New York.	293	"
Trinity Building, New York.	290	"
Capitol Building, Washington, D. C.	287½	"
Trinity Church.	286	"
Assinelli Tower, Bologna, Italy.	272	"
Pantheon, Paris.	274	"
Auditorium, Chicago.	270	"
Bank of Commerce Building, N. Y.	264	"
Column at Delhi, Hindoostan.	262	"
Porcelain Tower at Nankin, China.	262	"
Notre Dame Cathedral, Paris.	264	"
State Capitol, Hartford, Conn.	256	"
Fischer Building, Chicago.	235	"
Bunker Hill Monument, Massachusetts.	221	"
New Netherlands Hotel, N. Y.	220	"
Cathedral Notre Dame, Montreal, Canada.	220	"
Grace Church, New York.	216	"
St. John's Church, New York.	210	"
St Paul's, New York.	200	"
Leaning Tower of Pisa, Italy.	188	"
Ames Building, Boston.	186	"
Opera House, Paris.	183	"
Washington Monument, Baltimore.	175	"
July Column, Paris.	154	"
Nelson's Monument, Trafalgar Square, London.	154	"
Trajan's Pillar, Rome.	151	"
State, War, and Navy Building, Washington.	145	"
Obelisk of Luxor, Paris.	110	"

PART V.

THICKNESS, HEIGHT, ETC., OF BRICK WALLS. EXCAVATION TABLES. VARIOUS TABLES OF AREAS, CAPACITIES, ETC. MISCELLANEOUS RECEIPTS. MENSURATION TABLES. ODDS AND ENDS FOR THE NOON HOUR.

Thickness of Brick Walls of Various Heights as Allowed by the Chicago Building Code, 1905, for Various Buildings.

CLASS 1.—STORAGE AND MANUFACTURING BUILDINGS.

		Stories.											
	Basement.	1	2	3	4	5	6	7	8	9	10	11	12
One-story	12	12											
Two-story	16	12	12										
Three-story	16	16	12	12									
Four-story	20	20	16	16	12								
Five-story	24	20	20	16	16	16							
Six-story	24	20	20	20	16	16	16						
Seven-story	24	20	20	20	16	16	16	16					
Eight-story	24	24	24	20	20	20	16	16	16				
Nine-story	28	24	24	24	20	20	20	16	16	16			
Ten-story	28	28	28	24	24	24	20	20	20	16	16		
Eleven-story	28	28	28	24	24	24	20	20	20	16	16	16	
Twelve-story	32	28	28	28	24	24	24	20	20	20	16	16	16

CLASS 2.—OFFICE BUILDINGS, HOTELS, HOSPITALS, ETC.

		Stories.											
	Basement.	1	2	3	4	5	6	7	8	9	10	11	12
Basement and	12	8											
Two-story	12	12	8										
Three-story	16	12	12	12									
Four-story	20	16	16	12	12								
Five-story	20	16	16	16	12	12							
Six-story	20	20	16	16	12	12	12						
Seven-story	24	24	20	20	16	16	12	12					
Eight-story	24	24	24	20	20	16	16	12	12				
Nine-story	28	24	24	20	20	20	16	16	12	12			
Ten-story	28	24	24	24	20	20	20	16	16	12	12		
Eleven-story	28	28	24	24	24	20	20	20	16	16	12	12	
Twelve-story	32	28	28	24	24	24	20	20	20	16	16	12	12

CLASS 3.—RESIDENCES, STABLES, ETC.

	Base- ment.	Stories.											
		1	2	3	4	5	6	7	8	9	10	11	12
Basement and....	12	8											
Two-story.	12	12	8										
Three-story.	16	12	12	12									
Four-story.	20	16	16	12	12								
Five-story........	20	16	16	16	12	12							
Six-story.	20	20	16	16	16	12	12						
Seven-story.	24	24	20	20	16	16	12	12					
Eight-story......	24	24	24	20	20	16	16	12	12				
Nine-story.	28	24	24	20	20	20	16	16	12	12			
Ten-story........	28	24	24	24	20	20	20	16	16	12	12		
Eleven-story.	28	28	24	24	24	20	20	20	16	16	12	12	
Twelve-story.	32	28	28	24	24	24	20	20	20	16	16	12	12

CLASS 4.—HALLS FOR PUBLIC PURPOSES.—If such walls are less than 25 feet high, not less than 20 inches thick.

If they are more than 25 feet high and less than 45 feet high, they shall not be less than 24 inches thick.

If they are more than 45 feet and less than 60 feet high, they shall not be less than 28 inches thick.

If they are more than 60 feet and less than 75 feet high, they shall not be less than 32 inches thick.

If they are more than 75 feet and less than 90 feet high, they shall not be less than 36 inches thick.

An increase of 4 inches in thickness of such walls shall be made in all cases where they are over 100 feet long without cross-walls of equal height.

CLASS 5.—THEATRES.—The outside walls of all such buildings, the roofs or ceilings of which are carried on trusses or girders of a span of 50 feet or more, shall be as follows:

If such walls are less than 25 feet high, they shall be not less than 20 inches thick.

If they are more than 25 feet and less than 45 feet high, they shall be not less than 24 inches thick.

If they are more than 45 feet and less than 60 feet high, they shall be not less than 28 inches thick.

If they are more than 60 feet and less than 75 feet high, they shall be not less than 32 inches thick.

If they are more than 75 feet and less than 90 feet high, they shall be not less than 36 inches thick.

An increase of 4 inches in thickness of such walls shall be made in all cases where they are over 100 feet long, without cross-walls of equal height.

The thickness of the walls inclosing or surrounding rooms used for the purposes of Class V, where such rooms are less than 50 feet wide, may be reduced by 4 inches.

Class 6.—Tenement- and Apartment-houses, Flats or Double Houses.

	Base-ment.	Stories.											
		1	2	3	4	5	6	7	8	9	10	11	12
Basement and ...	12	8											
Two-story.......	12	12	8										
Three-story......	16	12	12	12									
Four-story.......	20	16	16	12	12								
Five-story.......	20	16	16	16	12	12							
Six-story........	20	20	16	16	16	12	12						
Seven-story.....	24	24	20	20	16	16	12	12					
Eight-story......	24	24	24	20	20	16	16	12	12				
Nine-story.......	28	24	24	20	20	20	16	16	12	12			
Ten-story........	28	24	24	24	20	20	20	16	16	12	12		
Eleven-story.....	28	28	24	24	24	20	20	20	16	16	12	12	
Twelve-story.....	32	28	28	24	24	24	20	20	20	16	16	12	12

Class 7.—Retail and Department Stores.

	Base-ment.	Stories.											
		1	2	3	4	5	6	7	8	9	10	11	12
One-story.......	12	12											
Two-story.......	16	12	12										
Three-story......	16	16	12	12									
Four-story.......	20	20	16	16	12								
Five-story.......	24	20	20	16	16	16							
Six-story........	24	20	20	20	16	16	16						
Seven-story.....	24	20	20	20	16	16	16	16					
Eight-story......	24	24	24	20	20	20	16	16	16				
Nine-story.......	28	24	24	20	20	20	16	16	16	16			
Ten-story........	28	28	28	24	24	24	20	20	20	16	16		
Eleven-story.....	28	28	28	24	24	24	20	20	20	16	16	16	
Twelve-story.....	32	28	28	28	24	24	24	20	20	20	16	16	16

CLASS 8.—SCHOOL BUILDINGS.

	Stories.					
	Base-ment. Inches.	1 Inches.	2 Inches.	3 Inches.	4 Inches.	5 Inches.
One-story.....	16	12				
Two-story.....	16	16	12			
Three-story ...	16	16	16	12		
Four-story.....	20	20	16	16	12	
Five-story.....	24	20	20	16	16	16

CUBIC YARDS OF EARTH IN DITCHES WITH SIDE SLOPES OF
ONE FOOT IN TEN.

Bottom Width.	Depth in Feet.											
	4	5	6	7	8	9	10	12	14	16	18	20
2 feet....	.36	.48	.60	.72	.86	.99	1.15	1.46	1.80	2.19	2.59	2.96
2½ "	.44	.57	.71	.85	1.01	1.16	1.33	1.68	2.06	2.48	2.92	3.33
3 "	.51	.66	.82	.98	1.16	1.33	1.51	1.90	2.32	2.80	3.25	3.70
3½ "	.59	.76	.93	1.11	1.30	1.49	1.70	2.12	2.58	3.10	3.58	4.07
4 "	.66	.84	1.04	1.24	1.45	1.66	1.88	2.34	2.84	3.40	3.91	4.44
4½ "	.74	.94	1.15	1.37	1.60	1.83	2.07	2.57	3.10	3.70	4.24	4.81
5 "	.81	1.04	1.26	1.50	1.75	2.00	2.25	2.80	3.36	4.00	4.57	5.18

Excavation Tables.

The following tables on pages 1 5 to 182 give the cubical contents in yards for each foot in depth of various excavations.

Example.—Find the number of yards in a cellar 24 × 40 feet, 8 feet deep. On page 178 we find 40 in the column of length, then follow this line out to the column under 24, the width, where we find 35.5, or 35.5 cubic yards for each foot of depth. Multiplying this by 8, we have the cubical contents of the cellar as 284 cubic yards.

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH.

From 2×6 to 16×35.

Width in Feet.

Length in Feet.	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	Length in Feet.
6																6
7																7
8																8
9																9
10																10
11																11
12																12
13																13
14																14
15																15
16																16
17																17
18																18
19																19
20																20
21																21
22																22
23																23
24																24
25																25
26																26
27																27
28																28
29																29
30																30
31																31
32																32
33																33
34																34
35																35

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH—*(Continued).*

From 17×6 to 30×35.

Width in Feet.

Length in Feet.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Length in Feet.
6															6
7															7
8															8
9															9
10															10
11															11
12															12
13															13
14															14
15															15
16															16
17															17
18															18
19															19
20															20
21															21
22															22
23															23
24															24
25															25
26															26
27															27
28															28
29															29
30															30
31															31
32															32
33															33
34															34
35															35

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH—(Continued).

FROM 2×36 TO 16×6b.

Length in Feet.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Length in Feet.
36	2.6	4.0	5.3	6.6	8.0	9.3	10.6	12.0	13.3	14.6	16.0	17.3	18.6	20.0	21.3	36
37	2.7	4.1	5.4	6.8	8.2	9.5	10.9	12.3	13.7	15.0	16.4	17.8	19.1	20.5	21.9	37
38	2.8	4.2	5.6	7.0	8.4	9.8	11.2	12.6	14.0	15.4	16.8	18.3	19.7	21.1	22.5	38
39	2.8	4.3	5.7	7.2	8.6	10.1	11.5	13.0	14.4	15.8	17.3	18.7	20.2	21.6	23.1	39
40	2.9	4.4	5.9	7.4	8.8	10.3	11.8	13.3	14.8	16.3	17.7	19.2	20.7	22.2	23.7	40
41	3.0	4.5	6.0	7.5	9.1	10.6	12.1	13.6	15.1	16.7	18.2	19.7	21.2	22.7	24.3	41
42	3.1	4.6	6.2	7.7	9.3	10.8	12.4	14.0	15.5	17.1	18.6	20.2	21.7	23.3	24.8	42
43	3.1	4.7	6.3	7.9	9.5	11.1	12.7	14.3	15.9	17.5	19.1	20.7	22.3	23.8	25.4	43
44	3.2	4.8	6.5	8.1	9.7	11.4	13.0	14.6	16.3	17.9	19.5	21.1	22.8	24.4	26.0	44
45	3.3	5.0	6.6	8.3	10.0	11.6	13.3	15.0	16.6	18.3	20.0	21.6	23.3	25.0	26.6	45
46	3.4	5.1	6.8	8.5	10.2	11.9	13.6	15.3	17.0	18.7	20.4	22.1	23.8	25.5	27.2	46
47	3.4	5.2	6.9	8.7	10.4	12.1	13.9	15.6	17.4	19.1	20.8	22.6	24.3	26.1	27.8	47
48	3.5	5.3	7.1	8.8	10.6	12.4	14.2	16.0	17.7	19.5	21.3	23.1	24.8	26.6	28.4	48
49	3.6	5.4	7.2	9.0	10.8	12.7	14.5	16.3	18.1	19.9	21.7	23.5	25.4	27.2	29.0	49
50	3.7	5.5	7.4	9.2	11.1	12.9	14.8	16.6	18.5	20.3	22.2	24.0	25.9	27.7	29.6	50
51	3.7	5.6	7.5	9.4	11.3	13.2	15.1	17.0	18.8	20.7	22.6	24.5	26.4	28.3	30.2	51
52	3.8	5.7	7.7	9.6	11.5	13.4	15.4	17.3	19.2	21.1	23.1	25.0	26.9	28.8	30.8	52
53	3.9	5.8	7.8	9.8	11.7	13.7	15.7	17.6	19.6	21.5	23.5	25.5	27.4	29.4	31.4	53
54	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0	54
55	4.0	6.1	8.1	10.1	12.2	14.2	16.3	18.3	20.3	22.4	24.4	26.4	28.5	30.5	32.5	55
56	4.1	6.2	8.3	10.3	12.4	14.5	16.5	18.6	20.7	22.8	24.8	26.9	29.0	31.1	33.1	56
57	4.2	6.3	8.4	10.5	12.6	14.7	16.8	19.0	21.1	23.2	25.3	27.4	29.5	31.6	33.7	57
58	4.2	6.4	8.5	10.7	12.8	15.0	17.1	19.3	21.4	23.6	25.7	27.9	30.0	32.2	34.3	58
59	4.3	6.5	8.7	10.9	13.1	15.3	17.4	19.6	21.8	24.0	26.2	28.4	30.5	32.7	34.9	59
60	4.4	6.6	8.8	11.1	13.3	15.5	17.7	20.0	22.2	24.4	26.6	28.8	31.1	33.3	35.5	60
61	4.5	6.7	9.0	11.3	13.5	15.8	18.0	20.3	22.5	24.8	27.1	29.3	31.6	33.8	36.1	61
62	4.5	6.8	9.1	11.4	13.7	16.0	18.3	20.6	22.9	25.2	27.5	29.8	32.1	34.4	36.7	62
63	4.6	7.0	9.3	11.6	14.0	16.3	18.6	21.0	23.3	25.6	28.0	30.3	32.6	35.0	37.3	63
64	4.7	7.1	9.4	11.8	14.2	16.5	18.9	21.3	23.7	26.0	28.4	30.8	33.1	35.5	37.9	64
65	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0	26.4	28.8	31.3	33.7	36.1	38.5	65

Width in Feet.

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH—(Continued).
From 17×36 to 30×65.

Length in Feet	Width in Feet														Length in Feet
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
36	22.6	24	25.3	26.6	28	29.3	30.6	32	33.3	34.6	36	37.3	38.6	40	36
37	23.2	24.6	26	27.4	28.7	30.1	31.5	32.8	34.2	35.6	37	38.3	39.7	41.1	37
38	23.9	25.3	26.7	28.1	29.5	30.9	32.3	33.7	35.1	36.5	38	39.4	40.8	42.2	38
39	24.5	26	27.4	28.8	30.3	31.7	33.2	34.6	36.1	37.5	39	40.4	41.8	43.3	39
40	25.1	26.6	28.1	29.6	31.1	32.5	34	35.5	37	38.5	40	41.4	42.9	44.4	40
41	25.8	27.3	28.8	30.3	31.8	33.4	34.9	36.4	37.9	39.4	41	42.5	44	45.5	41
42	26.4	28	29.5	31.1	32.6	34.2	35.7	37.3	38.8	40.4	42	43.5	45.1	46.6	42
43	27	28.6	30.2	31.8	33.4	35	36.6	38.2	39.8	41.4	43	44.5	46.1	47.7	43
44	27.7	29.3	30.9	32.5	34.2	35.8	37.4	39.1	40.7	42.3	44	45.6	47.2	48.8	44
45	28.3	30	31.6	33.3	35	36.6	38.3	40	41.6	43.3	45	46.6	48.3	50	45
46	28.9	30.6	32.3	34	35.7	37.4	39.1	40.8	42.5	44.2	46	47.7	49.4	51.1	46
47	29.5	31.3	33	34.8	36.5	38.2	40	41.7	43.5	45.2	47	48.7	50.4	52.2	47
48	30.2	32	33.7	35.5	37.3	39.1	40.8	42.6	44.4	46.2	48	49.7	51.5	53.3	48
49	30.8	32.6	34.4	36.2	38.1	39.9	41.7	43.5	45.3	47.1	49	50.8	52.6	54.4	49
50	31.4	33.3	35.1	37	38.8	40.7	42.5	44.4	46.2	48.1	50	51.8	53.7	55.5	50
51	32.1	34	35.8	37.7	39.6	41.5	43.4	45.3	47.2	49.1	51	52.8	54.7	56.6	51
52	32.7	34.6	36.5	38.5	40.4	42.3	44.2	46.2	48.1	50	52	53.9	55.8	57.7	52
53	33.3	35.3	37.2	39.2	41.2	43.1	45.1	47.1	49	51	53	54.9	56.9	58.8	53
54	34	36	38	40	42	44	46	48	50	52	54	56	58	60	54
55	34.6	36.6	38.7	40.7	42.7	44.8	46.8	48.8	50.9	52.9	55	57	59	61.1	55
56	35.2	37.3	39.4	41.4	43.5	45.6	47.7	49.7	51.8	53.9	56	58	60.1	62.2	56
57	35.8	38	40.1	42.2	44.3	46.4	48.5	50.6	52.7	54.8	57	59.1	61.2	63.3	57
58	36.5	38.6	40.8	42.9	45.1	47.2	49.4	51.5	53.7	55.8	58	60.1	62.2	64.4	58
59	37.1	39.3	41.5	43.7	45.8	48	50.2	52.4	54.6	56.8	59	61.1	63.3	65.5	59
60	37.7	40	42.2	44.4	46.6	48.8	51.1	53.3	55.5	57.7	60	62.2	64.4	66.6	60
61	38.4	40.6	42.9	45.1	47.4	49.7	51.9	54.2	56.4	58.7	61	63.2	65.5	67.7	61
62	39	41.3	43.6	45.9	48.2	50.5	52.8	55.1	57.4	59.7	62	64.2	66.5	68.8	62
63	39.6	42	44.3	46.6	49	51.3	53.6	56	58.3	60.6	63	65.3	67.6	70	63
64	40.2	42.6	45	47.4	49.7	52.1	54.5	56.8	59.2	61.6	64	66.3	68.7	71.1	64
65	40.9	43.3	45.7	48.1	50.5	52.9	55.3	57.7	60.1	62.5	65	67.4	69.8	72.2	65

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH—(Continued).
FROM 31×36 TO 40×65.

Length in Feet	Width in Feet										Length in Feet
	31	32	33	34	35	36	37	38	39	40	
36	41.3	42.7	44.0	45.3	46.7	48.0	49.3	50.7	52.0	53.3	36
37	42.5	43.9	45.2	46.6	48.0	49.3	50.7	52.1	53.4	54.8	37
38	43.6	45.0	46.4	47.9	49.3	50.7	52.1	53.5	54.9	56.3	38
39	44.8	46.2	47.7	49.1	50.6	52.0	53.4	54.9	56.3	57.8	39
40	45.9	47.4	48.9	50.4	51.9	53.3	54.8	56.3	57.8	59.3	40
41	47.1	48.6	50.1	51.6	53.1	54.7	56.2	57.7	59.2	60.7	41
42	48.2	49.8	51.3	52.9	54.4	56.0	57.6	59.1	60.7	62.2	42
43	49.4	51.0	52.6	54.1	55.7	57.3	58.9	60.5	62.1	63.7	43
44	50.5	52.1	53.8	55.4	57.0	58.7	60.3	61.9	63.6	65.2	44
45	51.7	53.3	55.0	56.7	58.3	60.0	61.7	63.3	65.0	66.7	45
46	52.8	54.5	56.2	57.9	59.6	61.3	63.0	64.7	66.4	68.1	46
47	54.0	55.7	57.4	59.2	60.9	62.7	64.4	66.1	67.9	69.6	47
48	55.1	56.9	58.7	60.4	62.2	64.0	65.8	67.6	69.3	71.1	48
49	56.3	58.1	59.9	61.7	63.5	65.3	67.1	69.0	70.8	72.6	49
50	57.4	59.3	61.1	63.0	64.8	66.7	68.5	70.4	72.2	74.1	50
51	58.6	60.4	62.3	64.2	66.1	68.0	69.9	71.8	73.7	75.6	51
52	59.7	61.6	63.6	65.5	67.4	69.3	71.3	73.2	75.1	77.0	52
53	60.9	62.8	64.8	66.7	68.7	70.7	72.6	74.6	76.6	78.5	53
54	62.0	64.0	66.0	68.0	70.0	72.0	74.0	76.0	78.0	80.0	54
55	63.1	65.2	67.2	69.3	71.3	73.3	75.4	77.4	79.4	81.5	55
56	64.3	66.4	68.4	70.5	72.6	74.7	76.7	78.8	80.9	83.0	56
57	65.4	67.6	69.7	71.8	73.9	76.0	78.1	80.2	82.3	84.4	57
58	66.6	68.7	70.9	73.0	75.2	77.3	79.5	81.6	83.8	85.9	58
59	67.7	69.9	72.1	74.3	76.5	78.7	80.9	83.0	85.2	87.4	59
60	68.9	71.1	73.3	75.6	77.8	80.0	82.2	84.4	86.7	88.9	60
61	70.0	72.3	74.6	76.8	79.1	81.3	83.6	85.9	88.1	90.4	61
62	71.2	73.5	75.8	78.1	80.4	82.7	85.0	87.3	89.6	91.9	62
63	72.3	74.7	77.0	79.3	81.7	84.0	86.3	88.7	91.0	93.3	63
64	73.5	75.9	78.2	80.6	83.0	85.3	87.7	90.1	92.4	94.8	64
65	74.6	77.0	79.4	81.9	84.3	86.7	89.1	91.4	93.9	96.3	65

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH—(Continued).
FROM 41×36 TO 50×65

Length in Feet	Width in Feet										Length in Feet
	50	49	48	47	46	45	44	43	42	41	
36	66.7	65.3	64.0	62.7	61.3	60.0	58.7	57.3	56.0	54.7	36
37	68.5	67.1	65.8	64.4	63.0	61.7	60.3	58.9	57.6	56.2	37
38	70.4	69.0	67.6	66.1	64.7	63.3	61.9	60.5	59.1	57.7	38
39	72.2	70.8	69.3	67.9	66.4	65.0	63.6	62.1	60.7	59.2	39
40	74.1	72.6	71.1	69.6	68.1	66.7	65.2	63.7	62.2	60.7	40
41	75.9	74.4	72.9	71.4	69.9	68.3	66.8	65.3	63.8	62.3	41
42	77.8	76.2	74.7	73.1	71.6	70.0	68.4	66.9	65.3	63.8	42
43	79.6	78.0	76.4	74.9	73.3	71.7	70.1	68.5	66.9	65.3	43
44	81.5	79.9	78.2	76.6	75.0	73.3	71.7	70.1	68.4	66.8	44
45	83.3	81.7	80.0	78.3	76.7	75.0	73.3	71.7	70.0	68.3	45
46	85.2	83.5	81.8	80.1	78.4	76.7	75.0	73.3	71.6	69.9	46
47	87.0	85.3	83.6	81.8	80.1	78.3	76.6	74.9	73.1	71.4	47
48	88.9	87.1	85.3	83.6	81.8	80.0	78.2	76.4	74.7	72.9	48
49	90.7	88.9	87.1	85.3	83.5	81.7	79.9	78.0	76.2	74.4	49
50	92.6	90.7	88.9	87.0	85.2	83.3	81.5	79.6	77.8	75.9	50
51	94.4	92.6	90.7	88.8	86.9	85.0	83.1	81.2	79.3	77.4	51
52	96.3	94.4	92.4	90.5	88.6	86.7	84.7	82.8	80.9	79.0	52
53	98.1	96.2	94.2	92.3	90.3	88.3	86.4	84.4	82.4	80.5	53
54	100.0	98.0	96.0	94.0	92.0	90.0	88.0	86.0	84.0	82.0	54
55	101.9	99.8	97.8	95.7	93.7	91.7	89.6	87.6	85.6	83.5	55
56	103.7	101.6	99.6	97.5	95.4	93.3	91.3	89.2	87.1	85.0	56
57	105.6	103.4	101.3	99.2	97.1	95.0	92.9	90.8	88.7	86.6	57
58	107.4	105.3	103.1	101.0	98.8	96.7	94.5	92.4	90.2	88.1	58
59	109.3	107.1	104.9	102.7	100.5	98.3	96.2	94.0	91.8	89.6	59
60	111.1	108.9	106.7	104.4	102.2	100.0	97.8	95.6	93.3	91.1	60
61	113.0	110.7	108.4	106.2	103.9	101.7	99.4	97.1	94.9	92.6	61
62	114.8	112.5	110.2	107.9	105.6	103.3	101.0	98.7	96.4	94.1	62
63	116.7	114.3	112.0	109.7	107.3	105.0	102.7	100.3	98.0	95.7	63
64	118.5	116.1	113.8	111.4	109.0	106.7	104.3	101.9	99.6	97.2	64
65	120.4	118.0	115.6	113.1	110.7	108.3	105.9	103.5	101.1	98.7	65

LENGTH OF SIDE OF OCTAGON BAYS, ETC.

Example.—Find the length of the side of an octagon bay which projects 3 feet 7 inches from the square.

In the column length of square projection we find 3, the number of feet, and then follow this line out to column 7, the number of inches, where we find 5 0⅞ or 5 feet ⅞ of an inch, the length of the side of the octagon.

Inches.

Length of Square Projection.	0	1	2	3	4	5	6	7	8	9	10	11
1	1 5	1 6¾	1 7¾	1 9¼	1 10⅝	2 0⅜	2 1¼	2 2⅞	2 4⅜	2 5¼	2 7⅜	2 8⅝
2	2 10	2 11⅝	3 0⅝	3 2¼	3 8⅛	3 5⅝	3 6¾	3 7⅝	3 9⅜	3 10¼	4 0⅛	4 1⅝
3	4 3	4 4⅞	4 5¾	4 7¼	4 8⅞	4 10⅛	4 11½	5 0⅞	5 2⅛	5 3½	5 4⅞	5 6⅜
4	5 8	5 9⅜	5 10⅝	6 0¼	6 1⅛	6 3⅛	6 4¼	6 5¾	6 7	6 8¼	6 10¼	6 11⅜
5	7 1	7 2⅜	7 3⅞	7 5¼	7 6⅜	7 8⅜	7 9¼	7 10⅞	8 0⅛	8 1¼	8 3¼	8 4⅜
6	5 5⅞	8 7¼	8 8⅜	8 10¼	8 11¼	9 1	9 2⅞	9 3¾	9 5¼	9 6⅜	9 8	9 9¼
7	9 10¼	10 0¼	10 1⅜	10 3¼	10 4¼	10 6	10 7¼	10 8¼	10 10¼	10 11⅜	11 8	11 2⅞
8	11 3⅛	10 5⅛	11 6¼	11 8⅛	11 9¼	11 11	12 0¼	12 1⅜	12 3¾	12 4⅛	12 6	12 7¼
9	12 8⅜	12 10⅜	12 11¼	13 1⅛	13 2⅛	13 4	13 5⅜	13 6¼	13 8¼	13 9⅝	13 11	14 0⅞
10	14 1¾	14 3⅛	14 4⅝	14 6	14 7⅞	14 8¾	14 10¼	14 11⅝	15 1⅛	15 2¼	15 3¾	15 5½
11	15 6¾	15 6¾	15 9⅞	15 11	16 0¾	16 1¾	16 7¾	16 4⅝	16 6⅛	16 7¼	16 8⅞	16 10⅜
12	16 11¼	17 1⅛	17 2⅝	17 4	17 5⅞	17 6⅝	17 8¼	17 9¼	17 11¼	18 0¾	18 1⅝	18 3⅜
13	18 4¼	18 6⅝	18 7⅝	18 9	18 10¾	19 2	19 1¼	19 2¾	19 4⅝	19 5¼	19 6⅜	19 6⅜
14	19 9⅜	19 11	20 0⅜	20 1⅞	20 3¼	20 4¾	20 6¼	20 7¼	20 9	20 10⅜	20 11¾	21 1¾
15	21 2⅜	21 2	21 5⅜	21 6¾	21 8⅛	21 9¼	21 11⅛	22 0¼	22 2	22 3⅜	22 4⅛	22 6¼
16	22 7⅜	22 9	22 10⅜	22 11¼	23 1⅛	23 2¼	23 4⅜	23 5¼	23 7	23 8⅜	23 9¾	23 11¼
17	24 0⅜	24 2	24 3⅜	24 4⅞	24 6¼	24 7¾	24 9⅞	24 10¼	25 0	25 1⅜	25 2¼	25 4¼
18	25 5¼	25 6¾	25 8⅜	25 9¾	25 11¼	26 0¾	26 2	26 3⅜	26 4⅜	26 6¼	26 7⅞	26 9⅜

DEPTH OF KEYSTONES, OR ARCH-RINGS, FOR BRICK AND STONE ARCHES

Rise in Parts of the Span.

Span of Arch in Feet.	Stone Arch, Depth of Keystone, or Arch-ring.												Brick Arches. Number of 4-inch Rowlocks to Arch-ring.					
	½ Ft.	In.	⅓ Ft.	In.	¼ Ft.	In.	⅙ Ft.	In.	⅛ Ft.	In.	1/10 Ft.	In.	½	⅓	¼	⅙	⅛	1/10
2	0	6½	0	6¾	0	7	0	7¼	0	7¾	0	8¼	2	2	2	2	2	2
3	0	7	0	7	0	8	0	8	0	9	0	9½	3	3	3	3	3	3
4	0	8	0	8	0	9	0	8½	0	10	0	10½	3	3	3	4	4	4
5	0	9	0	9	0	9¾	0	9¾	0	11	0	11	4	4	4	4	5	5
6	0	9½	0	10	0	10½	0	10¾	0	11¼	0	11½	4	4	5	5	5	5
7	0	10½	0	10½	0	11	0	11½	1	0¾	1	1½	4	4	5	5	5	5
8	0	11	0	11¼	0	11¾	1	0	1	1¼	1	2¾	5	5	5	5	5	5
9	0	11½	0	11½	1	0½	1	0½	1	1½	1	2¾	5	5	5	5	5	6
10	1	0¾	1	0¼	1	1	1	1¼	1	2¼	1	3½	5	5	5	5	6	6
12	1	1¼	1	1	1	1¼	1	1¾	1	3	1	4½	5	5	5	5	6	6
14	1	2¼	1	1¾	1	2	1	2½	1	3¾	1	5¼	5	5	5	5	6	6
15	1	4	1	2½	1	4	1	3½	1	4½	1	6	5	5	5	5	6	7
20	1	5½	1	4½	1	6½	1	5¼	1	7¼	1	8¼	6	6	6	6	7	8
25	1	7	1	5½	1	7¾	1	7	1	9	1	10½	6	6	7	7	8	8
30	1	8½	1	7½	1	7¾	1	8½	1	11	2	0½	6	7	7	7	8	8
35	1	8½	1	8½	1	9½	1	10	2	0½	2	2¼	7	7	8	8	8	9
40	1	9½	1	9¾	1	10	2	1¼	2	2	2	4	8	8	8	8	9	9
50	1	11¾	2	2¼	2	3¾	2	2¼	2	5½	2	7	8	9	9	9	10	10
60	2	2½	2	6	2	7	2	4½	2	7½	2	9¾	9	9	10	10	10	11
80	2	5½	2	6	2	7	2	8½	2	7½	3	2¼	9	10	11	12	13	13
100	2	8½	2	9	2	10½	3	1¼	3	4	3	6½	11	12	12	13	14	15

TABLE GIVING AREA OF CIRCLES (IN SQUARE FEET).

D......	0 in.	1 in.	2 in.	3 in.	4 in.	5 in.
Ft.						
1.	.7854	.922	1.07	1.23	1.40	1.58
2.	3.14	3.41	3.69	3.98	4.28	4.59
3.	7.07	7.47	7.88	8.30	8.73	9.17
4.	12.58	13.10	13.64	14.19	14.75	15.32
5.	19.64	20.39	20.97	21.65	22.34	23.04
6.	28.27	29.06	29.87	30.68	31.50	32.34
7.	38.48	39.41	40.34	41.28	42.24	43.20
8.	50.27	51.32	52.37	53.46	54.54	55.64
9	63.62	64.80	66.00	67.20	68.42	69.64
10.	78.54	79.85	81.18	82.52	83.86	85.22
11.	95.03	96.48	97.93	99.40	100.88	102.37
12.	113.10	114.67	116.26	117.86	119.47	121.09
13.	132.73	134.44	136.16	137.89	139.63	141.38
14.	153.94	155.78	157.63	159.49	161.36	163.24
15.	176.72	178.68	180.66	182.65	184.66	186.67
16.	201.06	203.16	205.27	207.39	209.53	211.67
17	226.98	229.21	231.45	233.71	235.97	238.24
18.	254.47	256.83	259.20	261.59	263.98	266.39
19	283.53	286.06	288.52	291.04	293.56	296.11
20.	314.16	316.78	319.42	322.06	324.72	327.39

D......	6 in	7 in.	8 in.	9 in.	10 in.	11 in.
Ft.						
1.	1.77	1.97	2.18	2.41	2.64	2.89
2.	4.91	5.24	5.59	5.94	6.30	6.68
3.	9.62	10.08	10.56	11.04	11.54	12.05
4.	15.90	16.50	17.10	17.72	18.35	18.99
5.	23.76	24.48	25.22	25.97	26.73	27.49
6.	33.18	34.04	34.91	35.78	36.67	37.57
7.	44.18	45.17	46.16	47.17	48.19	49.22
8.	56.75	57.86	58.99	60.13	61.28	62.44
9	70.88	72.13	73.39	74.66	75.94	77.24
10	86.59	87.97	89.36	90.76	92.17	93.60
11	103.87	105.38	106.90	108.43	109.98	111.53
12	122.72	124.36	126.01	127.68	129.35	131.04
13.	143.14	144.91	146.69	148.49	150.29	152.11
14.	165.13	167.03	168.95	170.87	172.81	174.76
15	188.69	190.73	192.77	194.83	196.89	198.97
16	213.83	215.99	218.17	220.35	222.55	224.76
17	240.53	242.82	245.13	247.45	249.78	252.12
18	268.80	271.23	273.67	276.12	278.58	281.05
19	298.64	301.21	303.77	306.36	308.94	311.55
20	330.06	332.75	335.45	338.16	340.88	343.62

NUMBER OF GALLONS IN ROUND CISTERNS AND TANKS.

Depth in Feet.	Diameter in Feet.							
	5	6	7	8	9	10	11	12
5	735	1,060	1,440	1,875	2,380	2,925	3,550	4,237
6	881	1,270	1,728	2,250	2,855	3,510	4,260	5,084
7	1,028	1,480	2,016	2,625	3,330	4,095	4,970	5,931
8	1,175	1,690	2,304	3,000	3,805	4,680	5,680	6,778
9	1,322	1,900	2,592	3,375	4,280	5,265	6,390	7,625
10	1,469	2,110	2,880	3,750	4,755	5,850	7,100	8,472
11	1,616	2,320	3,168	4,125	5,250	6,435	7,810	9,319
12	1,762	2,530	3,456	4,500	5,705	7,020	8,520	10,166
13	1,909	2,740	3,744	4,875	6,180	7,605	9,230	11,013
14	2,056	2,950	4,032	5,250	6,655	8,190	9,940	11,860
15	2,203	3,160	4,320	5,625	7,130	8,775	10,650	12,707
16	2,356	3,370	4,608	6,000	7,605	9,360	11,360	13,554
17	2,497	3,580	4,896	6,375	8,080	9,945	12,070	14,401
18	2,644	3,790	5,184	6,750	8,535	10,530	12,780	15,248
19	2,791	4,000	5,472	7,125	9,010	11,115	13,490	16,095
20	2,938	4,210	5,760	7,500	9,490	11,700	14,200	16,942

Depth in Feet.	Diameter in Feet.							
	13	14	15	16	18	20	22	24
5	4,960	5,765	6,698	7,520	9,516	11,750	14,215	16,918
6	5,952	6,918	8,038	9,024	11,419	14,100	17,059	20,302
7	6,944	8,071	9,378	10,528	13,322	16,450	19,902	23,680
8	7,936	9,224	10,718	12,032	15,225	18,800	22,745	27,070
9	8,928	10,377	12,058	13,536	17,128	21,150	25,588	30,454
10	9,920	11,530	13,398	15,040	19,031	23,500	28,431	33,838
11	10,913	12,683	14,738	16,544	20,934	25,850	31,274	37,222
12	11,904	13,836	16,078	18,048	22,837	28,200	34,117	40,606
13	12,896	14,989	17,418	19,552	24,740	30,550	36,960	43,990
14	13,888	16,142	18,758	21,056	26,643	32,900	39,803	47,374
15	14,880	17,295	20,098	22,260	28,546	35,250	42,646	50,758
16	15,872	18,448	21,438	26,064	30,449	37,600	45,489	54,142
17	16,864	19,601	22,778	25,568	32,352	39,950	48,332	57,520
18	17,856	20,754	24,118	27,072	34,255	42,300	51,175	60,910
19	18,848	21,907	25,458	28,576	36,158	44,650	54,018	64,294
20	19,840	23,060	26,798	30,080	38,062	47,000	56,861	67,678

To find the number of gallons in a tank of unequal diameter multiply the inside bottom diameter in inches by the inside top diameter in inches, then this product by 34: point off four figures and the result will be the average number of gallons to one inch in depth of the tank.

NUMBER OF U. S. GALLONS IN RECTANGULAR TANKS.

For One Foot in Depth.

Width in Feet.	Length of Tank in Feet.										
	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
2	29.92	37.40	44.88	52.36	59.84	67.32	74.81	82.29	89.77	97.25	104.73
2.5	....	46.75	56.10	65.45	74.80	84.16	93.51	102.86	112.21	121.56	130.91
3	....	....	67.32	78.54	89.77	100.99	112.21	123.43	134.65	145.87	157.09
3.5	....	....	....	91.64	104.73	117.82	130.91	144.00	157.09	170.18	183.27
4	....	....	....	....	119.69	134.65	149.61	164.57	179.53	194.49	209.45
4.5	....	....	....	....	....	151.48	168.31	185.14	201.97	218.80	235.63
5	....	....	....	....	....	....	187.01	205.71	224.41	243.11	261.82
5.5	....	....	....	....	....	....	....	226.28	246.86	267.43	288.00
6	....	....	....	....	....	....	....	....	269.30	291.74	314.18
6.5	....	....	....	....	....	....	....	....	....	316.05	340.36
7	....	....	....	....	....	....	....	....	....	....	366.54

Width in Feet.	Length of Tank in Feet.									
	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
2	112.21	119.69	127.17	134.65	142.13	149.61	157.09	164.57	172.05	179.53
2.5	140.26	149.61	158.96	168.31	177.66	187.01	196.36	205.71	215.06	224.41
3	168.31	179.53	190.75	202.97	213.19	224.41	235.63	246.86	258.07	269.30
3.5	196.36	209.45	222.54	235.63	248.73	261.82	274.90	288.00	301.09	314.18
4	224.41	239.37	254.34	269.30	284.26	299.22	314.18	329.14	344.10	359.06
4.5	252.47	269.30	286.13	302.96	319.79	336.62	353.45	370.28	387.11	403.94
5	280.52	299.22	317.92	336.62	355.32	374.03	392.72	411.43	430.13	448.83
5.5	308.57	329.14	349.71	370.28	390.85	411.43	432.00	452.57	473.14	493.71
6	336.62	359.06	381.50	403.94	426.39	448.83	471.27	493.71	516.15	538.59
6.5	364.67	388.98	413.30	437.60	461.92	486.23	510.54	534.85	559.16	583.47
7	392.72	418.91	445.09	471.27	497.45	523.64	549.81	575.99	602.18	628.36
7.5	420.78	448.83	476.88	504.93	532.98	561.04	589.08	617.14	645.19	673.24
8	....	478.75	508.67	538.59	568.51	598.44	628.36	658.28	688.20	718.12
8.5	....	....	540.46	572.25	604.05	635.84	667.63	699.42	731.21	763.00
9	....	....	....	605.92	639.58	673.25	706.90	740.56	774.23	807.89
9.5	....	....	....	....	675.11	710.65	746.17	781.71	817.24	852.77
10	....	....	....	....	....	748.05	785.45	822.86	860.26	897.66
10.5	....	....	....	....	....	....	824.73	864.00	903.26	942.56
11	....	....	....	....	....	....	....	905.14	946.27	987.43
11.5	....	....	....	....	....	....	....	....	989.29	1032.3
12	....	....	....	....	....	....	....	....	....	1077.2

Example.—To find number of gallons in a rectangular tank that is 7.5 feet by 10 feet, the water being 4 feet deep: Look in extreme left-hand column for **7.5**, and opposite to this in column headed **10** read 561.04, which being multiplied by 4, the depth of water in the tank, gives 2244.2, the number of gallons required.

WEIGHT OF ROUGH GLASS PER SQUARE FOOT.

Thickness, inches............	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1
Weight, pounds............	2	2$\frac{3}{4}$	2$\frac{1}{2}$	5	7	8$\frac{1}{2}$	10	12$\frac{1}{4}$

DIMENSIONS OF TERRA-COTTA CHIMNEY-TOPS.

Outside Dimension at Base.	Inside Dimension at Base.	Inside Dimension at Top.	Height.
12 inches	10 inches	6½ inches	3 feet 0 inches
14 "	12 "	8½ "	3 " 6 "
14×14 "	12 ×12 "	8× 8 "	4 " 0 "
12×12 "	10 ×10 "	6× 6 "	4 " 0 "
8×10 "	6 × 8 "	6½ "	4 " 0 "
8×12 "	6 ×10 "	6½ "	4 " 0 "
8×14 "	6 ×12 "	6½ "	4 " 0 "
10×10 "	8 × 8 "	6½ "	4 " 0 "
8×10 "	6 × 8 "	6½ "	5 " 6 "
8×12 "	6 ×10 "	6½ "	5 " 6 "
8×14 "	6 ×12 "	6½ "	5 " 6 "
10×10 "	8 × 8 "	6½ "	5 " 6 "
10×14 "	8 ×12 "	8½ "	4 " 0 "
12×12 "	10 ×10 "	8½ "	4 " 0 "
10×14 "	8 ×12 "	8½ "	5 " 6 "
12×12 "	10 ×10 "	8½ "	5 " 6 "
10×20 "	8 ×18 "	8½ "	4 " 0 "
10×20 "	8 ×18 "	8½ "	5 " 6 "
14 "	12 "	8½ "	4 " 0 "
14 "	12 "	8½ "	4 " 0 "
10×10 "	8½× 8½ "	6½ "	4 " 0 "
12×12 "	10½×10½ "	8½ "	4 " 0 "
10×10 "	8½× 8½ "	6½ "	5 " 6 "
12×12 "	10½×10½ "	8½ "	5 " 6 "
14×14 "	12 ×12 "	8 "	5 " 0 "
16×16 "	14 ×14 "	8 × 8 "	4 " 9 "
14 "	12 "	9 "	4 " 0 "
12×12 "	10 ×10 "	7 × 7 "	4 " 0 "
12×12 "	10 ×10 "	7 × 7 "	3 " 0 "
12×12 "	10 ×10 "	7 × 7 "	4 " 0 "
13×13 "	11 ×11 "	8 "	3 " 0 "
15×15 "	12½×12½ "	10 "	3 " 9 "
12 "	10 "	6½ "	3 " 3 "
14 "	12 "	8½ "	4 " 0 "
12 "	10 "	6½ "	3 " 3 "
12 "	10 "	6½ "	3 " 3 "
14 "	12 "	8½ "	4 " 0 "
12 "	10 "	6½ "	3 " 3 "
12 "	10 "	6½ "	3 " 3 "
16×16 "	14 ×14 "	8 × 8 "	2 " 0 "
22×22 "	20 ×20 "	12 ×12 "	1 " 9 "

DIMENSIONS OF FIRE-TILE.

Shape.	Dimensions.	Shape.	Dimensions.
Square edge..	8× 8×2 inches 10×10×2 " 12×12×2 " 14×14×2 " 16×16×2 " 18×18×2 " 12× 6×2 " 14× 6×2 " 16× 6×2 " 18× 6×2 " 18× 6×6 " 24× 6×6 "	Square edge	24×12×2 inches 24×12×3 " 20×15×3 " 24×15×3 " 28×12×3 " 30×15×3 " 36×15×3 "
		Flanged edge	24×12×3 " 24×15×3 " 28×12×3 " 28×15×3 " 30×15×3 " 36×15×3 "

VARIOUS RECEIPTS AND SHORT CUTS.

Miscellaneous Receipts. — TEST FOR SEWER-GAS. — Saturate unglazed paper with a solution of 1 ounce pure lead acetate in half a pint of rain-water; let it partially dry, then expose in the room suspected of containing sewer-gas.

The presence of gas in any considerable quantity soon darkens or blackens the test-paper. A suspected joint of a pipe can be tested by wrapping with a single layer of white muslin, moistened with the above solution, and if gas is escaping it will darken the cloth.

TO CLEAN COPPER.—Take 1 ounce of oxalic acid, 6 ounces of rotten stone, ½ ounce of gum arabic, all in powder, 1 ounce of sweet-oil, and sufficient water to make a paste. Apply a small portion and rub dry with a flannel or leather.

REMOVAL OF STAINS FROM GRANITE. — A paste of 1 ounce of ox-gall, 1 gill of strong solution of caustic soda, 1½ tablespoonfuls of turpentine, with enough pipe-clay to make it thick, and scour well.

Or, mix together ¼ pound soft soap, 1 ounce washing-soda, and a piece of sulphate of soda as big as a walnut. Rub it over the surface proposed to clean, let it stand twenty-four hours, and then wash off; or, smoke and soot stains can be removed with a hard scrubbing-brush and fine sharp sand, to which add a little potash.

Or, use strong lye, or make a hot solution of 3 pounds of common washing-soda dissolved in 1 gallon of water. Lay it on the granite with a paint-brush.

TO CLEAN MARBLE.—Mix 2 parts by weight of sal-soda, 1 part powdered chalk or fine bolted whiting, and 1 part powdered pumice-stone with enough water to make a thin batter, and by the means of a scrubbing-brush apply it to the spots; then wash off with soap and water.

Or, to remove grease spots from marble, moisten fine whiting or fullers' earth with benzine, apply it in a thick layer to the spots, and let it remain for some time; then remove the dry paste and wash the spot with soap and water.

To extract oil stains from marble, make a paste by mixing 2 parts of fullers' earth, 1 part soft soap, and 1 part potash with

boiling water. Apply this paste to the spots and let it remain three or four hours.

To Remove Paint from Window Glass.—Put sufficient saleratus into hot water to make a strong solution, and with this saturate the paint which adheres to the glass. Let it remain until nearly dry, then rub it off with a woollen cloth.

To Make Modelling Clay.—Knead dry clay with glycerine instead of water, work thoroughly with the hands, moisten work at intervals of two or three days, and keep covered to prevent evaporation of moisture.

To Clean Paint.—When paint is washed with any strong alkaline solution, such as soda or strong soap, the oil of the paint is liable to be changed to soap and the paint is seriously injured. To avoid this, take some of the best whiting, and have ready some clean warm water and a piece of flannel, which dip into the water and squeeze nearly dry; then take up as much whiting as will adhere to it, apply it to the painted surface, when a little rubbing will quickly remove any dirt or grease stains. After this wash the part well with clean water, rubbing it dry with a soft chamois. Paint thus cleaned will look as well as when first put on, and the operation may be tried without fear of injury to the most delicate colors. It answers far better than the use of soap, and does not require more than one-half the time and labor. Another simple method is the following: Put a tablespoonful of aqua ammonia in a quart of moderately hot water, dip in a flannel cloth, and with this merely wipe over the surface of the woodwork. No rubbing is necessary. The first recipe is preferable, except where the paint is badly discolored.

To Age or Color Copper.—Add about 1 pound of powdered sal ammoniac to 5 gallons of water, dissolve it thoroughly, and let it stand at least twenty-four hours before putting it on the copper. Apply it to the copper with a brush, being sure to cover every place; let it stand for a day and sprinkle with water, using a brush to sprinkle the water on so that it will not run and streak the copper. After standing overnight the color will be as desired. The same effect can be produced by using vinegar and salt instead of the sal ammoniac, using ½ pound of salt to 2 gallons of vinegar.

To Remove Old Glass from Sash.—Take a hot iron and run along the surface of the putty, when it can easily be removed with a chisel.

To Remove Rust Stains.—To remove rust stains from wood wash the disfigured parts with a solution of 2 ounces of oxalic acid to 1 pint of hot water.

In fitting doors always keep the hollow side next the stop or rebate strip.

When hanging transoms, where possible, if the transom is to be hung at the top, hang them so that when they are open the glass will lay on the wood and not on the putty.

Wash-stands are usually set 2 feet 6 inches from the floor.

The relative strength of timbers is estimated by multiplying the breadth by the square of the depth.

Example.—How many times as strong is a joist $2\frac{1}{2}'' \times 15''$ when supported on its narrow side as when supported on its broad side? $2\frac{1}{2} \times 2\frac{1}{2} = 6\frac{1}{4}$, $6\frac{1}{4} \times 15 = 93\frac{7}{16}$, $15 \times 15 = 225$, $225 \times 2\frac{1}{2} = 562\frac{1}{2}$, $562\frac{1}{2} \div 93\frac{7}{16} = 6$, or six times stronger.

Bevel of Doors.—In fitting doors the lock-edge should be given a bevel of $\frac{1}{8}$ inch in $2\frac{1}{4}$ inches, as this is the standard bevel given the face of locks. If the door be narrow it may be necessary to give it a little more bevel than this in order to clear the jamb as the door opens.

Astragal of Sliding-doors.—The standard astragal-joint of sliding-doors has a $\frac{3}{4}$-inch half-round or bead, with a groove to receive it slightly larger to give a little play.

Height of Chairs, etc.—The height of a chair-seat above the floor is 18 inches. The height of a table above the floor is 2 feet 5 inches.

Size of Bedsteads.—A single bed is 3 to 4 feet wide. A three-quarter bed is 4 to 4 feet 6 inches wide. A double bed is 5 feet wide. All bedsteads are from 6 feet 6 inches to 6 feet 8 inches long.

Size of Pianos.—Upright pianos vary in size from 4 feet 8 inches to 5 feet 8 inches long, and from 2 feet 2 inches to 2 feet 8 inches in depth.

Size of Bowling-alley.—A regulation bowling-alley is 65 feet long, $3\frac{1}{2}$ feet wide, with an additional 10 feet of floor-space.

Size of Billiard-tables.—Billiard-tables are 4 feet by 8 feet, 4 feet 2 inches by 9 feet, and 5 feet by 10 feet.

Size of Horse-stalls.—Horse-stalls should be made 4 feet or 5 feet or over in width by 9 feet in length. They should never be made between 4 and 5 feet, as the horse is liable to cast himself.

Height of Horse-troughs.—Horse or cattle water-troughs

should be made about 26 inches from floor or ground to the top
of the trough.

HEIGHT OF HAND-RAILS.—The usual height of hand-rails is
about 2 feet 7 inches from the top of the step on line with the
riser of the step.

HEIGHT OF BASE IN ROOMS.—A good rule for the height of
base is to divide the height of the story by 10 and multiply
this answer by $\frac{5}{8}$, which will give the height of the base; or
make the base the same number of inches in height that the
story is in feet.

HEIGHT OF CHAIR-RAILS.—Chair-rails should be about 36
inches from the floor to top of rail. In some cases the height
is governed by the height of the window-stools.

HAND OR LOOSE-PIN BUTTS.—A loose-pin butt that will work
on a door opening from you to the right, when standing at the
opposite side of the partition from that which the door is hung,
is a right-hand butt, and a left-hand butt if it will work on a
door opening to the left. The same rule applies to locks.

ROPE-MOULDINGS.—Rope may be used as spiral mouldings in
circular and curved work where wooden mouldings could not
be employed without incurring extraordinary expense. The
rope should be soaked for a few hours in thin starch and glue,
equal parts, thoroughly mixed together.

When the rope is to be nailed in place wipe off all the adhesive
matter, then secure one end in place and twist the rope until
the strands appear more prominent than ordinarily, then nail
in place.

After the rope is secured in place take a pointed stick and
draw along the creases of the rope, thus bringing the strands
into more prominence. Such mouldings may be finished with
wood-filler, painted and varnished. Boiled oil can be used in
place of the mixture of starch and glue.

HAND OF STAIRWAYS.—If, in ascending stairway, the rail
is on the right-hand side it is a right-hand stairway. If the
rail is on the left-hand side then it is a left-hand stairway.

SPACING ROOF-LATH FOR SLATE OR SHINGLES.—When a roof
is sheathed with lath or strips they should be spaced the same
distance, centre to centre, that the slate or shingles are to show
to the weather.

BRIDGING PARTITIONS.—When bridging partitions tack a

stud horizontally across the face of the partition and draw all the studs into line. Then cut in the bridging and nail solid, and it will keep the studs in line. Straight partitions and true plastering can be obtained in this way with a little care.

HEIGHT OF WARDROBE-SHELVES. Shelves in wardrobes should be set about 5 feet 10 inches from the floor, when there is to be a cloak-rail under the shelf; the hooks on the cloak-rail should be about 5 feet 6 inches from the floor.

SETTING DOOR-JAMBS.—The openings for doors should be framed about ¾ inch larger than the outside measurement of the jambs, and in setting the jambs use shingles for wedging. A bunch of shingles on a job when the door-jambs are being set will save many an hours' time.

NAILING MOULDING OF DOORS.—When nailing the moulding in the panels of moulded doors care should be taken not to drive any nails so that they will come in the way of the bit when boring for the mortise of the lock. Many a bit has been spoiled and many an hours' time lost by nails driven where the mortise for the lock is to be cut. In some cases it is well to tack the piece of moulding at this point, leaving it to be nailed fast after the lock is cut in.

CEMENT FOR STOPPING FLAWS IN WOOD.—Put any quantity of fine sawdust of the same wood your work is made with into an earthen pan, and pour boiling water on it; stir it well, and let it remain for a week or ten days, occasionally stirring it. Then boil it for some time, and it will be of the consistency of pulp or paste. Put it into a coarse cloth and squeeze all the moisture from it. Keep for use, and, when wanted, mix a sufficient quantity of thin glue to make a paste; rub it well into the cracks, or fill up the holes in your work with it. When quite hard and dry clean your work off, and, if carefully done, you will scarcely discern the imperfection.

NAILING BASE AND MOULDING AT MANTELS.—In making a return of the base and moulding at a mantel never nail the base or moulding fast to the mantel. The mantel should be left free to be taken off the hooks at any time.

TO BEND MOULDINGS.—To bend a moulding around a circle rip the moulding into strips, each strip being a member of the moulding, so the joints will come at the intersections of the members; then each strip can be bent separately.

TO FIT DOORS.—In fitting doors a good rule is to make the space between the door and jamb just large enough so a silver

quarter will slide around the door; this will give sufficient space for the paint or varnish and for the door to work easily. Always fit the door so that the hollow side lays against the stop or rebate.

DRIVING NAILS UNDER WATER.—To drive nails under water take a piece of pipe long enough to set on the timber, or whatever it is the nail is to be driven into; place it on the timber and drop the nail into it point first, then drop an iron rod down on top of the nail, and use the hammer on top of the rod to drive the nail.

SOUNDNESS OF TIMBER.—The soundness of timber may be ascertained by placing the ear close to one end of the timber while another person strikes a succession of blows on the opposite end, using a hammer or mallet. If the stick is sound the blows of the hammer will sound clear, but if they sound dull it indicates an unsound place in the timber.

CORNER-BLOCKS.—When putting up block-trim always set the corner-blocks so the grain will stand vertical, the end wood will then not show at the side.

SIDE OF AN OCTAGON.—To find the length of one side of an octagon when the short diameter is given multiply this diameter by 0.4141.

RADIUS OF DOOR- OR WINDOW-OPENINGS.—The radius of a segment, door, or window head should be equal to the width of the opening.

RELATIVE STRENGTH OF TIMBERS.—Beams of timber, when laid with their concentric layers vertical, are stronger than when laid horizontal in the proportion of 8 to 7.

TO CUT A STICK SQUARE OR ON AN ANGLE OF 45° WITHOUT A SQUARE.—Place the saw on the stick in a position to saw, and note the reflection of the stick on the side of the saw. If the reflection and the stick are in a line, then the saw is in a position to make a square cut. If the reflection and the stick are at right angles, then the saw is in position for a square mitre or angle of 45°.

TO FIND THE POWER OF A LEVER.—*Rule.*—As the distance between the weight and the fulcrum is to the distance between the power and the fulcrum so is the power to the weight.

TO FIND THE POWER OF PULLEYS OR SET OF BLOCKS.—*Rule.*—As one is to twice the number of movable pulleys so is the power to the weight.

SIZE OF GUTTERS AND DOWN-SPOUTS OR CONDUCTOR-PIPES.—

A rule of the American Bridge Company requires the following sizes for gutters and conductor-pipes:

· Size of Roof.	Gutter.	Conductor.
Up to 50 feet.	6 inches.	4 inches every 40 feet
50 " 70 "	7 "	5 " " 40 "
70 " 100 "	8 "	5 " " 40 "

PASTE FOR PAPER TO IRON.   For pasting paper to iron or steel mix dextrine with water and boil it down until it assumes about the consistency of very thin glue; it will not hold on greasy or oily substances.

INK FOR ZINC.—An ink which can be used with a drawing-pen on zinc and which is acid-proof is made of 1 dram verdigris, 1 dram sal-ammoniac powder, and $\frac{1}{2}$ dram lampblack, mixed with 10 drams of water.

OIL FOR OIL-STONES.—A good oil for oil-stones is made by mixing equal parts of sperm- and carbon-oil (coal-oil).

NAILING IN HARDWOODS. — When working in hardwoods bore a hole in the end of the hammer-handle and fill with soap or beeswax.   When a nail is to be driven place the point of it in the beeswax or soap and it will drive much easier.

PENNY AS APPLIED TO NAILS.—The term " penny " is derived from pound. · It originally meant so many pounds to the thousand.   Threepenny nails would mean three pounds to the thousand nails; eightpenny nails, eight pounds to the thousand nails, etc.

TO MARK TOOLS, ETC.—Take 7 ounces of nitric acid and 1 ounce of muriatic acid; mix, and shake together, then cover the tool where it is desired to mark with beeswax, and take a needle or other sharp instrument and scratch the name plainly in the beeswax; then apply the acid with a feather, filling up the scratch in the wax; let it remain for about five minutes, then wash off with water and rub with oil.

TO ADJUST A LEVEL.—Place the level against a wall or some solid place, and in position so that the bead in the glass is at the centre and mark the position of both ends of the level on the wall; now reverse the level; place one end to one of the marks made, and move the other end until the bead is in the centre again and mark the second position; now divide the space between the two marks made and place the end of the level to this mark, and turn the adjusting-screw of the level until it brings the bead to the centre, when the level will be true.

IMPROVED MARKING-GAUGE.—An improvement is made on the ordinary marking-gauge by boring a hole in one end and splitting the gauge so that a lead-pencil can be inserted and held. If there is not spring enough in the wood to hold the pencil put in a small screw to clamp the two sides together and hold the pencil.

TO FIT KEYS.—To fit a key in a lock when the lock cannot be taken out hold the key over a flame until it is well smoked; then place carefully in the lock and turn it as far as possible; then take out, and where it strikes and needs filing will be marked in the soot.

RESILIENCE OF TIMBER.—Comparative resilience of various kinds of timbers: ash being 1; fir, 4; elm, 54; pitch-pine, 57; teak, 59; oak, 63; spruce, 64; yellow pine, 64; cedar, 66; chestnut, 73; larch, 84; beech, 86. (By resilience is understood the quality of springing back or toughness.)

INCREASE OF STRENGTH OF TIMBER BY SEASONING.—Percentage of increase, strength of different woods by seasoning: white pine, 9%; elm, 12.3%; oak, 26.6%; ash, 44.7%; beech, 61.9%.

TRESTLES, STEP-LADDERS, ETC.—When making trestles, step-ladders, etc. for use during the construction of a building, make the legs 4 feet apart, centre to centre, so they will span, and set securely on the joist, whether spaced 12 or 16 inches on centres.

SIZE OF DENTILS.—The size of dentils vary according to the order of architecture in which they are used, but a good rule for proportioning the size of dentils is as follows:

$$\text{Width} = \tfrac{7}{12} \text{ of length;}$$
$$\text{Thickness} = \tfrac{7}{12} \text{ of length;}$$
$$\text{Space between} = \tfrac{1}{2} \text{ of width;}$$

A GOOD PAINT FOR ROOFS OR OUTBUILDINGS.—Take 1 gallon of crude petroleum and add to it slowly 3 pounds of Prince's Brown Metallic, mix thoroughly, and if necessary thin down with a little coal-oil. Apply in the same manner as ordinary paint.

TO FILE A SAW.—When filing a saw use the file with the point toward the handle of the saw, as this leaves the ragged edge on the back of the tooth and keeps the cutting edge of the tooth sharp.

SIZE OF A FLOUR-BARREL.—A flour-barrel is 28 to 30 inches in height, and 20 to 21 inches in diameter.

To Swing a Door over an Uneven Floor.—To swing a door over an uneven floor, or one that rises where the door swings so that the door rubs, use a wide butt at the bottom and a narrow one at the top of the door. This will raise the front of the door as it is opened. Two sizes of butts can also be used in this manner, to give a little gravity to the door to keep it closed.

Sheathing Paper Back of Frames.—When sheathing paper is used on a building and the siding is to be cut between the casings and the corner-boards always run a strip of the paper under the casings and corner-boards as they are put on; this strip of paper can then be lapped on the paper as it is put on and makes a tight job.

Nailing Bridging.—Do not nail the bottom end of floor bridging until after the floor is laid, as the floor then brings the joist into line.

TABLES CONVENIENT FOR TAKING INSIDE DIMENSIONS.

A box $24 \times 24 \times 14.7$ inches will hold a barrel of $31\frac{1}{2}$ gallons.
A box $15 \times 14 \times 11$ inches will hold 10 gallons.
A box $8\frac{1}{4} \times 7 \times 4$ inches will hold a gallon.
A box $4 \times 4 \times 3.6$ inches will hold a quart.
A box $24 \times 28 \times 16$ inches will hold 5 bushels.
A box $16 \times 12 \times 11.2$ inches will hold a bushel.
A box $12 \times 11.2 \times 8$ inches will hold a half-bushel.
A box $7 \times 6.4 \times 12$ inches will hold a peck.
A box $8.4 \times 8 \times 4$ inches will hold a half-peck, or 4 dry quarts.
A box $6 \times 5\frac{3}{5} \times 4$ inches will hold a half-gallon.
A box $4 \times 4 \times 2\frac{1}{10}$ inches will hold a pint.

Fire-brick.—Fire-brick are made by a similar process to making ordinary brick, but from different material. The clay used is known as fire-clay. This clay is composed of hydrated silicates of alumina, associated with silica and alumina in various states or subdivisions and sufficiently free from alkalies, iron, and lime to resist vitrification at high temperature.

Oxide of iron or sulphate of iron in the clay is very injurious, and when found in the brick in a quantity of more than 5 per cent they should be rejected. Lime, soda, potash, and magnesia are also injurious and any fire-brick containing over 3 per cent of either should be rejected.

Good fire-clay should contain 50 to 80 per cent of silica and 18 to 35 per cent of alumina; it should be of a uniform texture and have a greasy feel between the fingers.

Fire-brick which are to be exposed to heat should be laid in fire-clay, and should be thoroughly wet before laying; the mortar should be used very thin and the joint made as tight as possible.

VITRIFIED BRICK are brick burned to a hard glossy consistency so as to be impermeable to water and fit for damp-proof work, paving, and such purposes.

LAYING FIRE-BRICK.—*Fire-clay.*—Fire-clay is *not a cement*, and it has little or no holding power. Its office is therefore not to act as a binder, but merely to fill the voids. In consequence a fire-brick joint is the more perfect in proportion as the quantity of fire-clay approaches the amount necessary to fill the voids, without preventing the brick from touching, precisely as in case of a glue joint between pieces of wood. Clay of consistency suffici nt to permit use of trowel should not be permitted; the proper way is to mix the clay to requisite thinness, dip each brick into the clay, "rub and shove" each brick into final place, then drive it with mallet or hammer and block until it actually touches the brick below it. *Rigid adherence to these directions is absolutely essential when constructing fire-arch s.*

The two defects of fire-clay are its shrinkage during drying and its lack of cementing power. The former may be greatly diminished b adding to the clay about 20 per cent of its volume of fire-brick pulverized nd sifted to *fire-brick flour.* This can be obtained in many places, ut unless it is of the requisite fineness, avoid it, as coarse material will thicken the joints an amount which offsets t e adv nt ge.

The cemen ing power of fire-clay may be increased by adding to and slacking in with it about $1\frac{1}{4}$ per cent of its volume of lime; measure the clay and for each cubic foot put in a piece of lime not exceeding $4'' \times 2'' \times \frac{1}{2}''$. This will have just sufficient fluxing power to unite with the cl y and f rm a hard clinker which takes a grip on th fire-brick. It should always be used when building arches.

After all is done ive the joints several coats of clay wash, which should be made of a thin solution of fire-clay and be applied with a whitewash-brush.

From 600 to 800 pounds of fire-clay is enough to lay 1000 brick.

All fire-bric work should be warmed up slowly to expel moisture before applying severe heat.

GENERAL RULES FOR BRICK CHIMNEYS OR STACKS.—The diameter of the base should not be less than one-tenth of the height if square; if round, one-twelfth of the height.

Batter of chimneys, 0.03 inch to the foot.

The thickness of the brickwork should be one brick, from top, to 25 feet from same; a brick and a half from 25 to 50 feet from the top, increasing by the half-brick every 25 feet from the top. If the inside diameter at the top exceeds 4 feet 6 inches, the top length should be a brick and a half.

Four courses of brickwork will lay 1 foot in height in a chimney.

In building chimneys from stoves or fireplaces never connect two fires to one flue or neither one may burn satisfactorily; each fire should have a separate flue running to the top of the chimney.

FIREPLACE OPENINGS IN CHIMNEYS.—Fireplace openings for grates should be about 2 feet 5 inches in height from the floor, and about 6 inches larger in width than the size grate to be used so as to allow for the fire-brick lining.

An iron bar $\frac{3}{4}$ inch by 3 inches makes the best arch for over a fireplace. If a brick arch is used it should be a flat jack-arch.

IRON BOND IN BRICK WALLS.—In brick walls where great strength is desired flat iron, say $\frac{3}{16}'' \times 3''$, can be bedded in the walls at certain intervals running lengthwise of the wall.

When the walls of the Palace Hotel, San Francisco, were built, iron bond of this kind was built in the walls to give them strength to withstand the shocks of earthquakes. That it fulfilled the purpose for which it was put in the walls is shown by the fact that the walls of the building were not damaged by the earthquake when this part of the city was destroyed, but the building was destroyed by fire.

BRICK FOR LAYING CIRCLE WALLS.—Brick for laying circle walls should be made to conform to the desired radius if the circle has a radius of less than 7 feet. Brick to lay a radius of 7 feet or over can be selected from straight brick, as the brick to lay a 7-foot radius has a curve of but $\frac{1}{16}$ inch to a brick.

The curve of brick to lay various circles are as follows:

Brick to work to a radius of 1 foot should have a curve of $1\frac{1}{16}$ inch to the brick.

Brick to work to a radius of 1 foot 6 inches should have a curve of $\frac{1}{2}$ inch to the brick.

Brick to work to a radius of 2 feet should have a curve of $\frac{5}{16}$ inch to the brick.

Brick to work to a radius of 2 feet 6 inches should have a curve of $\frac{1}{4}$ inch to the brick.

Brick to work to a radius of from 3 feet to 4 feet should have a curve of $\frac{3}{16}$ inch to the brick.

Brick to work to a radius of from 4 feet to 6 feet should have a curve of $\frac{1}{8}$ inch to the brick.

Brick to work to a radius of from 6 feet to 7 feet should have a curve of $\frac{1}{16}$ inch to the brick.

LIME MORTAR IN THICK WALLS.—Pure lime mortar should not be used in any thick, heavy masonry. Pure lime mortar requires air to cause it to harden or set, and if used in the interior of thick walls is liable to dry out without attaining any strength whatever.

In all thick walls a hydraulic lime or lime and cement mortar should be used.

MASONS' PLUMB-RULE. — The spirit plumb-rule is now generally used by all masons, and is quicker but not so reliable as the old plumb-bob. A spirit plumb-rule should be tested often to see if true; a knock or jar may move the glass a little and make the rule untrue. A good way is for the mason to test his plumb-rule every morning before starting to work.

To test the plumb-rule, hold it up against the side of a house or some solid object and when the "bead" shows plumb scribe a mark on the wall at top and bottom of the rule, now turn the rule over, place the edge of the rule again to the marks, and if the "bead" shows plumb the rule is true, but if not it should be adjusted as explained for adjusting the level on page 194.

To REMOVE STAINS FROM STONE.—Take fullers' earth and make a paste to which add a little lye; spread this on the stain and let dry, then wash clean. It may require two or three applications to take out the stain.

To SELECT A MALLET OR HAMMER-HANDLE.—In selecting a wooden mallet or a hammer-handle, pick out a light-colored one, as this is the sap-wood and is tougher than the dark wood, which comes from the heart of the tree. Tests have shown that the

toughest part of the tree is the sap-wood or part next the bark just above the ground.

SIZE OF BRICK TO LAY ENGLISH CROSS BOND.—Brick to work English cross bond: the length of the brick must equal twice the width plus the thickness of one mortar joint.

Thus, brick 8″ long to lay English cross bond with $\frac{1}{4}$″ joint must be $3\frac{7}{8}$″ wide.

A NEW METHOD FOR CLEANING STONEWORK has just been given a practical trial by the Treasury Department. The whole of the Treasury Building has been cleaned for the first time in 40 years. The work was done in 50 days and the change in the appearance of the building from a sooty gray to granite white s as striking as if it had been rebuilt of new stone. The cleaning has been done by the aid of a liquid preparation invented by Mr. James F. Bruce, of Washington, D. C. The ingredients of the liquid are secret, but the inventor has applied for a patent. The liquid is colorless and does not in any way injure the stone. It is applied with an ordinary paint-brush, and this is followed by a wet sponge which seems to gather up the cleaning liquid and the dirt. The work is finished by the application of a hose and the granite appears as clean as if new. The result is said to be as satisfactory as the sand-blast method for granite and other hard stone, though inapplicable to sandstone. It is also much less disagreeable to owners of neighboring property and to passers-by. The chief advantage of the process lies, however, in its extreme cheapness and in the ease and rapidity with which it is applied.

EFFLORESCENCE.—When the face of some walls become wet or damp they will be covered with a sort of white efflorescence; it is in some cases a nitrate or carbonate of potash, more frequently a carbonate or sulphate of soda. There is no way to prevent this unless by coating the bricks with some preparation to render them water- and moisture-proof.

SIZE OF A BRICK-HOD.—A brick-hod measures 8 inches on the sides and 20 to 22 inches in length, and will carry 16 to 20 bricks.

SIZE OF MORTAR-HOD.—The mortar-hod is usually made about 22 inches in length and 12 to 14 inches deep on the sides.

STAIN FOR STAINING BRICKS.—For staining bricks red, melt 1 ounce of glue in 1 gallon of water, add a piece of alum the size of an egg, then $\frac{1}{4}$ pound Venetian red and 1 pound of Spanish

brown. Try the color on the bricks before using and change light or dark with the red or brown, using a yellow mineral for buff.

ARTIFICIAL MARBLE.—According to M. Maard, artificial marble may be produced in the following manner: 10 parts of burnt gypsum and 1 part of alum are mixed together in a little water. This is then calcined and afterward reduced to a powder. To 25 parts of the powder is added 22 parts of talc, 5 parts of magnesium chloride, 44 parts of clay, and 1 part of potassic alum. This mixture can be worked polished, or painted similar to marble.

PROTECTION OF STONEWORK.—The stone belt course and all stone trimmings should be carefully protected from the mortar of the brickwork above. This can be done by building in a strip of heavy building paper (not tar paper) under the first course of brick above the stone, letting the paper hang out over the stone so as to shed the mortar droppings. The paper should be let into the joint about 1 inch and can be cut off when the walls are washed down.

TO BRIGHTEN OLD BRICKWORK.—To make brickwork look new and bright apply a wash as follows: Take ½ pound of glue, soak it in water overnight and then dissolve it in about 8 gallons of water, then add 1 ounce of bichromate of potash in solution and 10 pounds of dark Venetian red and enough yellow ochre to give the desired shade. Apply the wash as thin as possible with a large whitewash-brush.

TO CLEAN BRICKWORK.—Mix together 1 pint of liquid ammonia, 1 gallon soft soap, 2 pounds powdered pumice. This will make a soft paste which can be applied with a brush. Dust off the brickwork and apply a coat of the mixture and after letting it stand about twenty minutes scrub it off, using a scrubbing-brush and clean water. Then rinse off with a hose.

MENSURATION TABLES, ETC.

LINEAR MEASURE.

1 hair's breadth.	=	$\frac{1}{48}$ inch.
3 barleycorns (lengthwise) . .	=	1 inch.
7.92 inches.	=	1 link.
12 inches.	=	1 foot = 0.3048 metre.
3 feet.	=	1 yard = 0.91438 metre.
5½ yards.	=	1 rod, perch, or pole.
4 poles or 100 links.	=	1 chain.
10 chains.	=	1 furlong.
8 furlongs.	=	1 mile = 1.6093 kilometres
		= 5280 ft.
3 miles (nautical).	=	1 league.
1 line.	=	$\frac{1}{12}$ inch.
1 nail (cloth measure).	=	2¼ inches.
1 palm.	=	3 inches.
1 hand (used for height of horses).	=	4 inches.
1 span.	=	9 inches.
1 cubit.	=	18 inches.
1 pace (military).	=	2½ feet.
1 pace (common).	=	3 feet.
1 Scotch ell.	=	37.06 inches.
1 vara (Spanish).	=	33.3 inches.
1 English ell.	=	45 inches.
1 fathom.	=	6 feet.
1 cable's length.	=	120 fathoms.
1 "knot".	=	6082.66 feet.
1 degree of equator.	=	69.1613 statute miles.
1 degree of meridian.	=	69.046 statute miles
1 degree of equator.	=	60 geographical miles.
1 degree of meridian.	=	59.899 geographical miles.
1.1527 statute miles.	=	1 geographical mile.
6086.07 feet.	=	1 minute of longitude = 1 nautical mile.

SQUARE OR SURFACE MEASURE.

144 square inches. . . . . . . = 1 square foot.

   9 square feet. . . . . = 1 square yard = 1296 square inches.

100 square feet. . . . . = 1 square (builders' measure).

LAND MEASURE.

30¼ square yards........	=1 square rod.	
40 square rods.........	=1 square rood	=1210 square yards.
4 square roods.......	=1 acre	=4840 square yards.
640 acres...............	=1 square mile.	
208.71 feet square...... ..	=1 acre.	
1 square mile.........	=1 section of land.	
160 acres...............	=¼ section of land.	

CUBIC MEASURE.

1728 cubic inches...........	=1 cubic foot.
27 cubic feet.............	=1 cubic yard.
128 cubic feet.............	=1 cord.
40 cubic feet....	=1 American shipping ton.
42 cubic feet.............	=1 British shipping ton.
108 cubic feet.............	=1 stack of wood.
24.75 cubic feet of stone......	=1 perch.

Note.—In Oklahoma, North Dakota, South Dakota, and Ohio a perch is fixed at 25 cu. ft. of stone. In Delaware it is 24¾ cu. ft. in walls, 27 cu. ft. when piled on the ground, 30 cu. ft. when in a boat, and 30½ cu. ft. in cars. In Colorado a perch of stone in mason work is 16½ cu. ft., and for brickwork measure laid in a wall, 22 bricks per cubic foot for a foot wall and 15 bricks for what is known as an 8-inch wall. In Philadelphia 22 cu. ft. is considered a perch.

AVOIRDUPOIS WEIGHT (ORDINARY COMMERCIAL WEIGHT).

16 drams........... =	1 ounce, oz.
16 ounces........... =	1 pound, lb.
28 lbs. (old)........ =	1 quarter, qr.
4 quarters (old) } .. =	1 hundredweight.
100 lbs., pounds }	
20 hundredweight... =	1 ton.
100 pounds......... =	1 cental.
175 troy pounds..... =	144 avoirdupois.
1 troy pound....... =	5760 grains.
1 avoirdupois pound =	7000 grains.

Avoirdupois weight is used to weigh all coarse articles, as hay, meat, fish, potash, groceries, flax, butter, cheese, etc., and metals, except precious metals. Formerly the usual custom was to allow 112 pounds for a hundredweight and 28 pounds for a

quarter, but this practice has very nearly passed away. The custom-house still adheres to the old usage.

APOTHECARIES' MEASURE—LIQUID.

60 minims or drops, m.,	=1 fluid drachm.
8 fluid drachms.	=1 fluid ounce.
16 fluid ounces.	=1 pint (octarius).
8 pints.	=1 gallon (congius).

These apothecarie ' weights and measures are used by apothecaries and physicians in compounding medicines, but drugs and medicines are bought and sold by avoirdupois weight.

The standard avoirdupois pound is the weight of 27.7015 cubic inches of distilled water weighed in air at 39.1°, the barometer at 30 inches.

APOTHECARIES' WEIGHT—DRY.

20 grains. .	=1 scruple.
3 scruples	=1 dram.
8 drams. .	=1 ounce.
12 ounces	=1 pound.

LIQUID OR WINE MEASURE.

4 gills.	=1 pint, pt.
2 pints.	=1 quart, qt.
4 quarts	=1 gallon, gal.
42 gallons.	=1 tierce.
1½ tierces or 63 gallons. . . .	=1 hogshead, hhd.
84 gallons.	=1 puncheon.
1½ puncheons or 126 gallons	=1 pipe.
2 pipes.	=1 tun.
231 cubic inches.	=1 gallon.
10 gallons.	=1 anker.
18 "	=1 runlet.
31½ "	=1 barrel.

This measure is used to measure water, wine, spirits, cider, oil, honey, etc. In London the gill is usually called a quartern.

ALE OR BEER MEASURE.

2 pints.....	=1 quart.
4 quarts....	=1 gallon.
9 gallons....	=1 firkin.
2 firkins....	=1 kilderkin.
2 kilderkins	=1 barrel.
$1\frac{1}{2}$ barrels....	=1 hogshead.
$1\frac{1}{3}$ hogsheads	=1 puncheon.
$1\frac{1}{2}$ puncheons	=1 butt.

Used to measure beer, ales, porter, etc. An ale gallon measures 282 cubic inches.

ENGLISH WINE MEASURE.

18 U. S. gallons....	=1 runlet.
25 English gallons $\big\}$	=1 tierce.
42 U. S. gallons	
$7\frac{1}{2}$ English gallons..	=1 firkin of beer.
4 firkins.........	=1 barrel.
$52\frac{1}{4}$ English gallons $\big\}$	=1 hogshead.
63 U. S. gallons	

DRY MEASURE.

2 pints... =1 quart .. =	67.2	cubic inches.	
4 quarts. =1 gallon .. =	288.8	"	"
2 gallons. =1 peck.... =	537.6	"	"
4 pecks.. =1 bushel.. =	2150.42	"	"
36 bushels =1 chaldron =	57.244	"	feet.
4 bushels (in England) =1 coon.			
2 coons " " =1 quarter.			
5 quarters " " =1 wey.			
2 weys " " =1 last.			

A gallon, dry measure, measures $268\frac{4}{5}$ cubic inches.

SURVEYORS' SQUARE MEASURE.

625 square links	=1 square rod, sq. rd.
16 " rods	=1 " chain, sq. ch.
10 " chains	=1 acre, A.
640 acres	=1 square mile, sq. mi.
36 square miles or 6 miles square	= 1 township, tp.

SURVEYORS' LONG MEASURE.

$$
\begin{array}{ll}
7.92 \text{ inches} . . & = 1 \text{ link.} \\
25 \text{ links} . . . . & = 1 \text{ pole.} \\
100 \text{ links} . . . . & = 1 \text{ chain.} \\
10 \text{ chains} . . & = 1 \text{ furlong.} \\
8 \text{ furlongs} & = 1 \text{ mile.}
\end{array}
$$

Used by surveyors, civil engineers, etc., in measuring distances.

MEASURE OF TIME.

$$
\begin{array}{ll}
60 \text{ seconds, sec.} . . . . . & = 1 \text{ minute, min.} \\
60 \text{ minutes.} . . . . & = 1 \text{ hour, hr.} \\
24 \text{ hours.} . . . . & = 1 \text{ day, dy} \\
7 \text{ days.} . . . . & = 1 \text{ week, wk.} \\
2 \text{ weeks.} . . . . & = 1 \text{ fortnight.} \\
4 \text{ weeks.} . . . . & = 1 \text{ month, mo.} \\
13 \text{ months 1 day 6 hrs.} & = 1 \text{ Julian year.} \\
365 \text{ days 6 hours} . . . . . . & = 1 \text{ Julian year.} \\
366 \text{ days.} . . . . & = 1 \text{ leap year.} \\
12 \text{ calendar months} . . & = 1 \text{ year.}
\end{array}
$$

Used for computing time.

CIRCULAR MEASURE.

$$
\begin{array}{ll}
60 \text{ seconds, } '' . . & = 1 \text{ minute, } '. \\
60 \text{ minutes.} . . . . & = 1 \text{ degree, } °. \\
30 \text{ degrees.} . . . . & = 1 \text{ sign, s.} \\
90 \text{ degrees.} . . . . & = 1 \text{ quadrant.} \\
12 \text{ signs} . . . . . . & = \text{a circle.}
\end{array}
$$

$$
\left. \begin{array}{l} 4 \text{ quadrants} \\ 360 \text{ degrees} . . \end{array} \right\} = \text{a circumference of a circle.}
$$

Used in measuring latitude, longitude, etc.

TROY WEIGHT.

Used in Weighing Gold or Silver.

$$
\begin{array}{ll}
24 \text{ grains.} . . . . . . & = 1 \text{ pennyweight.} \\
20 \text{ pennyweights} & = 1 \text{ ounce.} \\
12 \text{ ounces.} . . . . . & = 1 \text{ pound.}
\end{array}
$$

A carat of the jewellers, for precious stones, is, in the United States, 3.2 grains; in London, 3.17 grains; in Paris 3.18 grains are divided into 4 jewellers' grains. In troy, apothecaries', and avoirdupois weights the grain is the same.

MEASURES OF VALUE.
U. S. Standard.

10 mills. . = 1 cent.
10 cents. . = 1 dime.
10 dimes = 1 dollar.
10 dollars = 1 eagle.

The standard of gold and silver is 900 parts of pure metal and 100 parts of alloy to 1000 parts of coin.

WEIGHT OF COIN.

Double eagle. . . . . . . = 516 troy grains.
Eagle. . . . . = 258 troy grains.
Dollar (gold). . . . . . . = 25.8 troy grains.
Dollar (silver). . . . . . = 412.5 troy grains.
Half dollar. . . . . = 192 troy grains.
5-cent piece (nickel) = 77.16 troy grains.
3-cent piece (nickel) = 30 troy grains.
Cent (copper). . . . . . = 48 troy grains.

NUMBER OF ENGLISH OR UNITED STATES YARDS IN MILES OF DIFFERENT NATIONS.

Name.	Yards.	Name.	Yards.
Arabian.	2,148	Luthenian.	9,784
Bohemian.	10,187	Oldenburg.	10,820
Brebant.	6,082	Persian (paisang).	6,082
Burgundy.	6,183	Polish (long).	8,101
Chinese (Hls).	682	Polish (short).	6,095
Dutch (Ure).	6,395	Portuguese (leguos). . . .	6,760
Danish.	8,244	Prussian.	8,498
English (U. S.).	1,760	Roman (modern).	2,035
English (geographical). .	2,025	Roman (ancient).	1,613
Flemish.	6,869	Russian (verst).	1,167
German (geographical) .	8,100	Saxon.	9,905
Hamburg.	8,244	Scotch.	1,984
Hanover.	11,559	Silesian.	7,083
Hesse.	10,547	Spanish (leguas).	4,630
Hungarian.	9,113	Spanish (com.).	7,416
French (art leagues) . . .	4,860	Swiss.	9,166
French (marine).	6,075	Swedish.	11,704
Legal Le'g'e (2000 toises)	4,263	Turkey.	1,821
Irish.	3,338	Tuscan.	1,808
Italian.	2,025	Vienna (post mile).	8,296

TABLE OF MISCELLANEOUS WEIGHTS.

14 pounds. . . . . =1 stone (horseman's weight).
56 pounds. . . . . =1 firkin of butter.
64 pounds. . . . . =1 firkin of soft soap.
112 pounds. . . . . =1 barrel of raisins.
256 pounds. . . . . =1 pack of soft soap.
196 pounds. . . . . =1 barrel of flour.
200 pounds. . . . . =1 barrel of beef, pork, or fish.
280 pounds. . . . . =1 barrel of salt, New York.
22 stones (301 lbs.). . . . . =1 sack of wool.
17 stones 2 lbs. (240 lbs.) =1 pack of wool.
60 pounds. . . . . =1 truss of hay (new).
50 pounds. . . . . =1 truss of hay (old).
40 pounds. . . . . =1 truss of straw.
400 pounds. . . . . =1 bale of cotton.
100 pounds. . . . . =1 quintal of fish.

COMMON WEIGHTS AND MEASURES AND THEIR METRIC EQUIVALENTS.

An inch =2.54 centimetres.
A foot =.3048 metre.
A yard =.9144 metre.
A rod =5.029 metres.
A mile =1.6093 kilometres.
A square inch =6.452 square centimetres.
A square foot =.0929 sq. m.
A square yard =.8361 sq. m.
An acre =.4047 hectare.
A square mile =259 hectares.
A cubic foot =.02832 cu. m.
A cubic yard =.7646 cu. m.
A cord =3.624 steres.

A liquid quart =.9465 litre.
A gallon =3.786 litres.
A dry quart =1.101 litres
A peck =8.811 litres.
A bushel =35.24 litres.
An ounce avoirdupois =28.35 grams.
A pound avoirdupois =.4336 kilogram.
A ton =.9072 tonneau.
A grain troy =.0648 gram.
An ounce troy =31.104 grms.
A pound troy =.3732 kgrm.

U. S. Land Measure.

A range is a line of townships running north and south, and is known by its number east or west of the principal meridian.

A township is divided into 36 equal squares, called sections, each 1 mile square, and containing 640 acres.

A section is variously divided for purposes of sale.　The U. S. Land Office recognizes the following divisions:

Half-section. . . . . $= 1 \times \frac{1}{2}$ mile $= \frac{1}{2}$　sq. mile $= 320$ acres
Quarter-section. . . . . $= \frac{1}{2} \times \frac{1}{2}$ mile $= \frac{1}{4}$　sq. mile $= 160$ acres
Half-quarter-section . . . . . . $= \frac{1}{2} \times \frac{1}{4}$ mile $= \frac{1}{8}$　sq. mile $=\ 80$ acres
Quarter-quarter-section. . . . $= \frac{1}{4} \times \frac{1}{4}$ mile $= \frac{1}{16}$ sq. mile $=\ 40$ acres

Old French Linear and Land Measure.

12 lines. . . . . $= 1$ inch　　　6 feet. . . . . $= 1$ toise
12 inches. . . . . $= 1$ foot　　　32 toises. . . . . $= 1$ arpent
　　　　　　1024 sq. toises. . . . . . $= 1$ sq. arpent

The French foot equals 12.79 English inches.

The arpent is the old French name for acre, and contains nearly $\frac{5}{6}$ of an English acre.

SPANISH LAND MEASURE.

Sometimes used in Texas, Mexico New Mexico, Arizona, and California.

26,000,000	sq. varas (sq. of 5099	varas) $= \begin{cases} 1 \text{ league} \\ 1 \text{ labor} \end{cases}$	$= 4605.5$	acres.
1,000,000	sq. varas (sq. of 1000	varas) $= 1$ labor	$=\ 177.136$	acres.
25,000,000	sq. varas (sq. of 5000	varas) $= 1$ league	$= 4428.4$	acres.
12,500,000	sq. varas (sq of 3535.5	varas) $= \frac{1}{2}$ league	$= 2214.2$	acres.
8,333,333	sq. varas (sq. of 2886.7	varas) $= \frac{1}{3}$ league	$= 1476.13$	acres.
6,250,000	sq. varas (sq. of 2500	varas) $= \frac{1}{4}$ league	$= 1107.1$	acres.
7,225,600	sq. varas (sq. of 2688	varas)	$= 1280$	varas.
3,612,800	sq. varas (sq. of 1900.8	varas) $= 1$ section	$=\ 640$	acres.
1,806,400	sq. varas (sq. of 1344	varas) $= \frac{1}{2}$ section	$=\ 320$	acres.
903,200	sq. varas (sq. of 950.44	varas) $= \frac{1}{4}$ section	$=\ 160$	acres.
451,600	sq. varas (sq. of 672	varas) $= \frac{1}{8}$ section	$=\ 80$	acres.
225,800	sq. varas (sq. of 475	varas) $= \frac{1}{16}$ section	$=\ 40$	acres.
5,645.376	sq. varas (sq. of 75.137	varas) $= 4840$ sq. yd.	$=\ 1$	acre.

To find the number of acres in any number of square varas multiply the latter by 177 (or to be more exact, by $177\frac{1}{7}$), and cut off six decimals.

1 vara $= 33\frac{1}{3}$ inches.　　　　1900.8 varas $= 1$ mile.

WEIGHTS AND MEASURES OF THE PHILIPPINES.

1 polgrada (12 linea)........................ =	.927	inch
1 pie.................................. =	11.125	inches
1 vara................................. =	33.375	inches
1 gantah.............................. =	.8796	gallon
1 caban............................... =	21.991	gallons
1 libra (16 onzo)....................... =	1.0144	lb. av.
1 arroba.............................. =	25.360	lb. av.
1 catty (16 tael)....................... =	1.94	lb. av.
1 pecul (100 catty)..................... =	139.482	lb. av.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL OF VARIOUS COM-
MODITIES PREPARED BY DEPARTMENT OF COMMERCE AND
LABOR, BUREAU OF STANDARDS, WASHINGTON.

The list below includes products for which legal weights have
been fixed in but one or two States.

Apple seeds, 40 pounds (Rhode Island and Tennessee).

Beggarweed seed, 62 pounds (Florida).

Blackberries, 32 pounds (Iowa); 48 pounds (Tennessee); dried,
28 pounds (Tennessee).

Blueberries, 42 pounds (Minnesota).

Bromus inermus, 14 pounds (North Dakota).

Cabbage, 50 pounds (Tennessee).

Canary seed, 60 pounds (Tennessee).

Cantaloupe melon, 50 pounds (Tennessee).

Cement, 80 pounds (Tennessee).

Cherries, 40 pounds (Iowa); with stems, 56 pounds (Tennessee);
without stems, 64 pounds (Tennessee).

Chestnuts, 50 pounds (Tennessee); 57 pounds (Virginia).

Chufa, 54 pounds (Florida).

Cottonseed, staple, 42 pounds (South Carolina).

Cucumbers, 48 pounds (Missouri and Tennessee); 50 pounds
(Wisconsin).

Currants, 40 pounds (Iowa and Minnesota).

Feed, 50 pounds (Massachusetts).

Grapes, 40 pounds (Iowa); with stems, 48 pounds (Tennessee);
without stems, 60 pounds (Tennessee).

Guavas, 54 pounds (Florida).

Hickory nuts, 50 pounds (Tennessee).

Hominy, 60 pounds (Ohio); 62 pounds (Tennessee).

Horseradish, 50 pounds (Tennessee).

Italian rye-grass seed, 20 pounds (Tennessee).

Johnson grass, 28 pounds (Arkansas).

Kaffir corn, 56 pounds (Kansas).   ˙

Kale, 30 pounds (Tennessee).

Land plaster, 100 pounds (Tennessee).

Meal, 46 pounds (Alabama); unbolted, 48 pounds (Alabama).

Middlings, fine, 40 pounds (Indiana); coarse middlings, 30 pounds (Indiana).

Millet, Japanese barnyard, 35 pounds (Massachusetts).

Mustard, 30 pounds (Tennessee).

Plums, 40 pounds (Florida); 64 pounds (Tennessee).

Plums, dried, 28 pounds (Michigan).

Popcorn, 70 pounds (Indiana and Tennessee); in the ear, 42 pounds (Ohio).

Prunes, dried, 28 pounds (Idaho); green, 45 pounds (Idaho).

Quinces, 48 pounds (Florida, Iowa, and Tennessee).

Rape-seed, 50 pounds (Wisconsin).

Raspberries, 32 pounds (Kansas); 48 pounds (Tennessee).

Rhubarb, 50 pounds (Tennessee).

Sage, 4 pounds (Tennessee).

Salads, 30 pounds (Tennessee).

Sand, 130 pounds (Iowa).

Spelt or spiltz, 40 pounds (North Dakota); 45 pounds (South Dakota).

Spinach, 30 pounds (Tennessee).

Strawberries, 32 pounds (Iowa); 48 pounds (Tennessee).

Sugar-cane seed, 57 pounds (New Jersey.)

Velvet-grass seed, 7 pounds (Tennessee).

Walnuts, 50 pounds (Tennessee).

On the pages following are tabulated the products for which legal weights have been more widely established.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL.

| | Apples. | | | Beans. | | | | | | | | |
	Apples.*	Dried Apples.	Barley.	Beans.*	Castor Beans (shelled).	Beets.	Blue-grass Seed.	Bran.*	Broom-corn Seed.	Buckwheat.	Carrots.	Charcoal.
U. S.	....	....	48	....	50	....	....	....	....	42	....	....
Alabama.	....	21	47	60	....	....	....	....	....	....	....	....
Arizona. .	....	....	45	a55	....	....	....	....	....	....	....	....
Arkansas.	b50	24	48	a60	....	....	14	20	48	52	....	....
California.	....	....	50	....	....	....	....	....	....	40	....	....
Colorado.	....	....	48	60	....	....	14	....	....	52	....	....
Conn.	48	25	48	60	....	c60	....	20	....	48	50	20
Delaware.	....	....	....	....	....	....	....	....	....	....	....	20
Florida. ...	b48	24	48	d60	48	....	....	20	....	....	....	....
Georgia. ..	....	24	47	e60	....	....	14	f20	....	52	....	....
Hawaii. ..	....	....	48	....	....	....	....	....	....	....	....	....
Idaho.	b45	28	48	....	....	....	....	....	....	42	....	....
Illinois. ...	....	24	48	e60	46	....	14	20	....	52	....	....
Indiana. ..	....	25	48	60	46	....	14	....	....	50	....	....
Iowa.	48	21	48	60	46	....	14	20	30	52	....	20
Kansas...	b48	24	48	60	46	....	g14	20	....	50	....	....
Kentucky	b48	24	47	e60	*45	....	14	20	....	56	....	....
Louisiana.	....	....	48	....	....	....	....	....	....	....	....	....
Maine. ...	44	....	48	60	....	60	....	....	....	48	50	....
Maryland	....	....	....	....	....	....	....	....	....	....	....	20
Mass.	48	25	48	h60	....	....	....	20	....	48	50	....
Michigan.	48	22	48	60	46	....	14	....	....	48	....	....
Minnesota	b50	28	48	60	....	50	14	....	57	50	45	20
Mississippi	....	26	48	e60	46	....	14	20	....	48	....	....
Missouri. .	48	24	48	i60	46	....	14	20	....	52	50	....
Montana.	45	....	48	60	....	50	14	20	....	52	50	....
Nebraska	....	24	48	e60	46	....	14	20	....	52	....	....
New Ham.	....	....	....	62	....	....	....	....	....	....	....	....
N. Jersey.	50	25	48	60	....	....	....	....	....	50	....	....
New York	48	25	48	60	....	....	....	20	....	48	50	....
N. Car. ..	....	....	48	....	....	....	....	....	....	50	....	....
N. Dakota	50	....	48	60	....	60	....	20	30	42	....	....
Ohio.	50	24	48	60	....	56	....	....	....	50	50	....
Oklahoma	....	....	48	60	....	60	....	20	30	42	....	....
Oregon. ..	45	28	46	....	....	....	....	....	....	42	....	....
Penn....	....	....	47	....	....	....	....	....	....	48	....	jk18
R. Island.	48	25	48	60	46	50	....	20	....	48	50	20
S. Dakota	....	....	48	60	....	60	....	20	30	42	....	....
Tennessee	b50	24	48	il60	46	50	14	20	42	50	50	22
Texas. ...	45	28	48	e60	....	....	....	20	....	42	....	22
Vermont.	46	....	48	62	....	60	....	....	....	48	50	....
Virginia..	....	28	48	e60	....	....	14	....	....	52	....	....
Wash.. ...	b45	28	48	....	....	....	....	....	....	42	....	....
W. Va....	....	25	48	60	....	....	....	....	....	52	....	....
Wisconsin	50	25	48	60	....	50	....	20	....	50	50	....

* Not defined.

a Small white beans, 60 pounds.
b Green apples.
c Sugar beets and mangel wurzel.
d Shelled beans, 60 pounds; velvet beans, 78 pounds.
e White beans.
f Wheat bran.
g English blue-grass seed, 22 pounds; native blue-grass seed, 14 pounds.
h Soy beans, 58 pounds.
i Green unshelled beans, 30 pounds.
j Commercially dry, for all hard woods.
k Fifteen pounds, commercially dry, for all soft woods.
l Dried beans.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL—(Continued).

	Clover Seed.	Coal.*	Anthracite Coal.	Bituminous Coal.	Cannel Coal.	Mineral Coal.	Stone Coal.	Coke.	Corn.*	Corn in Ear, Husked.	Corn in Ear, Unhusked.	Shelled Corn.	Corn Meal.*
U. S.				80					56				48
Alabama.										70	75	56	
Arizona.									54				
Arkansas.	60									70	74	56	48
Colorado.	60	80					80			70			50
Conn.	60		80										
Florida.											70	56	48
Georgia.	60						80			70		56	48
Idaho.	60												
Illinois.	60						80			70		56	48
Indiana.	60				80					(a)		56	50
Iowa.	60						80	38		b 70		56	
Kansas.	60						80		c 70				50
Kentucky.	60	76	76	76	76	76	76		d 70			56	50
Louisiana.									56				
Maine.									56				e 50
Mass.	60											f 50	50
Michigan.	60				80					b 70		56	50
Minnesota	60	80								70		56	
Mississippi	60						80			72		56	48
Missouri.	60					80					70	56	50
Montana.	60						76			70		56	50
Nebraska	60						80			70		56	50
N. Hamp.									56				50
N. Jersey.	64												
New York	60												50
N. Car.	60												
N. Dakota	60						80			70		56	
Ohio.	60			30	70			40		68		56	
Oklahoma	60						80			70		56	
Oregon.	60												
Penn.	60	g 75		76				40	58				50
R. Island.	60	80						40		70		56	50
S. Car.													h 48
S. Dakota							80			70		56	
Tennessee	i 60						80	40		70	j 74	56	
Texas.	60						80			70	72	56	
Vermont.	60												
Virginia.	60						80			70		56	50
Wash.	60												
W. Va.	60			80					56				
Wisconsin	60												50

* Not defined.

a Corn in ear, 70 pounds until Dec. 1 next after grown; 68 pounds thereafter.
b In the cob.
c Indian corn in ear.
d Corn in ear, from Nov. 1 to May 1, following, 70 pounds; 68 pounds from May 1 to Nov. 1.

e Indian-corn meal.
f Cracked corn.
g Standard weight in borough of Greensburg.
h Standard weight bushel corn meal, bolted or unbolted, 48 pounds.
i Red and white.
j Green unshelled corn, 100 pounds.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL—(*Continued*).

	Corn Meal, Bolted.	Corn Meal, Unbolted.	Cottonseed.*	Sea Island Cottonseed.	Upland Cottonseed.	Cranberries.	Flaxseed (Linseed).	Gooseberries.	(Plastering) Hair.	Hemp Seed.	Herds Grass.	Hungarian Grass Seed.	Indian Corn or Maize.
			Cottonseed.										
U. S.							56						
Alabama.			32										
Arkansas.			33⅓				56						
California.													52
Colorado.											44		56
Conn.				44	30		55				45		56
Delaware	44	48											56
Florida.			32	46									
Georgia.			30				56		8	44			
Hawaii.													56
Idaho.							56						56
Illinois.							56		8	44			
Indiana.						33				44			
Iowa.							56	40	a8	44		50	
Kansas.							56		a8	44		50	b56
Kentucky							56		8	44		50	
Maine.									11		45		
Mass.				44	30		55				45		b56
Michigan.						40	56			44		50	
Minnesota						36		40	a8	50		48	
Mississippi	44	48	32				56			44		50	
Missouri.			33				56			44		48	
Montana.							56			44		50	
Nebraska							56		8	44		50	
N. Jersey.							55						56
New York				44	30		55				45		56
N Car.	46	48	30				55						56
N. Dakota							56						
Ohio.							56			44		50	
Oklahoma							56						
Oregon.													56
Penn.													56
R. Island.				44	30		56			44		50	
S. Car.	46	48	30	(c)			56						
S. Dakota							56						
Tennessee	50	48	28				56	48	8	44		48	
Texas.			32				56			44		48	
Vermont.											45		56
Virginia.			32				56		8	44	12	48	
Wash.							56						56
W. Va.							56						
Wisconsin				44	30		56		8	44		48	56

* Not defined.

a Unwashed plastering hair, 8 pounds; washed plastering hair, 4 pounds.   *b* Shelled.   *c* Matured.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL—(Continued).

	Lime.					Onions.					Peaches.	
	Lime.*	Unslaked Lime.	Malt.	Millet.	Oats.	Onions.*	Onion Sets.	Orchard Grass Seed.	Osage Orange Seed.	Parsnips.	Peaches.*	Dried Peaches, Peeled.
U. S.			34		32							
Alabama					32							38
Arizona					32							
Arkansas				50	32	57						33
California					32							
Colorado	80				32	57						
Conn.	70				32	52				45		33
Florida				50	32	56					a54	33
Georgia		80			32	57						38
Hawaii					32							
Idaho					36							
Illinois		80	38		32	57						
Indiana			b35	50	32	48		14	33	55		
Iowa	80			50	32	57			32		48	
Kansas		80	32	50	32	57						
Kentucky		35			c32	57	d36	14				39
Maine					e32	52				45		
Maryland					26							
Mass.	70				32	52						33
Michigan	70			50	32	54		14	33			28
Minnesota	80			48	32	52		14		42		28
Mississippi		80	38	50	32	57						33
Missouri			38	50	32	57	f28	14	36	44	48	33
Montana		80	30		32	57				50		
Nebraska		80	30	50	32	57	25		32			33
N. Hamp.					32							
N. Jersey					30	57						33
New York	70				32	57						33
N. Car.					32							
N. Dakota	80			50	32	52						
Ohio	70		34	50	32	55					48	33
Oklahoma	80				32	52						
Oregon					32							28
Penn.					32	50						
R. Island	70		38	50	32	50				50	48	33
S. Dakota	80				32	52						
Tennessee	(g)	80		h50	32	i56	j28	14	33	50	l50	26
Texas				50	32	57					50	28
Vermont					32	52						
Virginia		80	33	50	30	57	28	14	34			40
Washington					32							28
W. Virginia					32							33
Wisconsin	70	80	34	50	32	57				44		33

* Not defined.

a Green peaches.
b Malt rye.
c Shelled.
d Bottom onion sets.
e Strike measure.
f Top onion sets.

g Slaked lime, 40 pounds.
h German Missouri and Tennessee millet seed.
i Matured onions.
j Button onion sets, 32 pounds.
l Matured.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL—(Continued).

	Dried Peaches, Unpeeled.	Peanuts.	Pears.*	Pease.			Potatoes.			Red Top.	Rough Rice.	Rice Corn.	Rutabagas.
				Ground Pease.	Green Pease, Unshelled.	Pease.*	Potatoes.*	Sweet Potatoes.	White Potatoes.				
U. S.						60	60	55	60				
Alabama.	33					60		55	60				
Arkansas.	33					60	60	50		14			
Colorado.							60						
Conn.....	33					60	60	54	60		45		60
D. C.....							60						
Florida...		22	60	25		60		60	60				
Georgia..	33			25		60		55	60		43		
Idaho....	28		i45				60						
Illinois...	33							50	60				
Indiana..	33						60	55					
Iowa.....	33						60	46					
Kansas..	33						60	50				56	
Kentucky				24		60	60	55	60				
Maine....						60	60						60
Maryland.							56						
Mass.....						60	60	54			45		
Michigan						60		56	60	b14			
Minnesota						60		55	60	b14			52
Mississippi				24		60	60	60	60				
Missouri.			48		56	c60		56	60	b14			50
Montana.			45			60	60						
Nebraska						60		50	60				
N. Hamp.						60	60						
N. Jersey.						60		54	60				
New York						60		54	60		45		
N. Car ..		22				60					44		
N. Dakota						60		46	60				
Ohio						60		50	60				
Oklahoma						60		46	60				
Oregon...			45				60						
Penn.....							56						
R. Island.						c60		54	60				
S. Dakota						60		46	60				
Tennessee		23	d56		30	60		50	60	b14			
Texas ...								55	60				
Vermont						60	60						
Virginia..	32	22				e60		56	56	12			
Wash.....			a45				60						
W. Va....							60						
Wisconsin						60		54	60		45		56

* Not defined.

a Green.
b Seed
c Including split pease.

d Matured pears, 56 pounds; dried pears, 26 pounds.
e Black-eyed pease.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL—(*Continued*)

	Rye Meal.	Rye.	Salt.*	Fine Salt.	Coarse Salt.	Shorts.*	Sorghum Seed.	Tomatoes.	Timothy Seed.	Turnips.*	Common English Turnips.	Wheat.
U. S.		56								55		60
Alabama.		56								55		60
Arizona.		56										60
Arkansas		56	50				50		60	57		60
California.		54										60
Colorado.		56	80						45			60
Conn.	50	56		50	70	20					50	60
Delaware.												60
Florida.		56	60				56			54		60
Georgia.		56							45	55		60
Hawaii.		56										60
Idaho.		56										60
Illinois.		56		55	50				45	55		60
Indiana.		56	50						45	55		60
Iowa.		56	50				a30		45			60
Kansas.		56	50				56		45	55		60
Kentucky.		56	50	55					45	60		60
Louisiana.		56										60
Maine.	50	50		60	70						50	60
Maryland.								60				
Mass.	50	56		50	70	20			45			60
Michigan.		56	56						45	58		60
Minnesota.		56					57		45			60
Mississippi.		56	50				42		45	55		60
Missouri.		56	50				42	45	45		42	60
Montana.		56	50						45	50		60
Nebraska.		56	50				30		45	55		60
N. Hamp.	50	56										60
N. Jersey.		56										60
New York.	50	56		56	70	20			45			60
N. Carolina.		56										60
N Dakota.		56	80						45	60		60
Ohio.		56						56	45	60		60
Oklahoma.		56	80						42	60		60
Oregon.		56										60
Penn.		56		c62	85							60
R. Island.	50	56		50	70	20		56	45	50		60
S. Dakota		56	80						42	60		60
Tennessee.		56	50				50	56	45	50		60
Texas		56	50					55	45	55		60
Vermont.		56	70						45	60		b60
Virginia		56	50						45	55		60
Washington.		56										60
W. Virginia.		56							45			60
Wisconsin.	50	56		50	70	20			45	42		60

* Not defined.

a Sorghum saccharatum seed,   c Ground salt, 70 pounds.
b India wheat, 46 pounds.

RULES RELATIVE TO THE CIRCLE.

To Find Circumference:

    Multiply diameter by 3.1416,
    or divide   "   " 0.3183.

To Find Diameter:

    Multiply circumference by 0.3183,
    or divide   "   " 3.1416.

To Find Radius:

    Multiply circumference by 0.15915,
    or divide   "   " 6.28318.

To Find Side of an Inscribed Square:

    Multiply diameter by   0.7071,
    or multiply circumference by 0.2251,
    " divide   "   " 4.4428.

To Find Side of an Equal Square:

    Multiply diameter by   0.8862,
    or divide   "   "   1.1284,
    " multiply circumference by 0.2821,
    " divide   "   " 3.545.

Square.

    A side multiplied by 1.1442 equal diameter of its circumscribing circle.

    A side multiplied by 4.443 equal circumference of its circumscribing circle.

    A side multiplied by 1.128 equal diameter of an equal circle.

    A side multiplied by 3.547 equal circumference of an equal circle.

    Square inches multiplied by 1.273 equal circle inches of an equal circle.

To Find the Area of a Circle:

    Multiply circumference by one-quarter of the diameter,
    or multiply the square of diameter   by 0.7854,
    "   "   "   "   " circumference " 0.07958,
    "   "   "   "   " ½ diameter   " 3.1416.

To Find the Surface of a Sphere or Globe:

> Multiply the diameter by the circumference,
> or multiply the square of diameter by 3.1416,
> "   "   four times the square of radius by 3.1416.

To Find the Weight of Brass and Copper Sheets, Rods, and Bars:

> Ascertain the number of cubic inches in piece and multiply same by weight per cubic inch.
>
> Brass,   0.2972.
>
> Copper, 0.3212.
>
> Or multiply the length by the breadth (in feet) and product by weight in pounds per square foot.

TABLE TO FIND AREAS, ETC., OF POLYGONS.

Name of Polygon.	No. of Sides.	A Area.	B Radius of Circumscribed Circle.	C Length of the Side.	D Radius of Inscribed Circle.	Angle Contained between Two Sides.
Triangle........	3	0.433013	0.5773	1.732	0.2887	60°
Tetragon......	4	1	0.7071	1.4142	0.5	90°
Pentagon......	5	1.720477	0.8506	1.1756	0.6882	108°
Hexagon.......	6	2.598076	1	1	0.866	120°
Heptagon......	7	3.633912	1.1524	0.8677	1.0383	128.57°
Octagon........	8	4.828427	1.3066	0.7653	1.2071	135°
Nonagon......	9	6.481824	1.4619	0.684	1.3737	140°
Decagon.......	10	7.694209	1.618	0.618	1.5383	144°
Undecagon....	11	9.36564	1.7747	0.5634	1.7028	147.27°
Dodecagon...	12	11.196152	1.9319	0.5176	1.866	150°

To find the area of a regular polygon when the length of one side is given: Multiply the square of the side by the multiplier opposite to the name of the polygon in column A of the following table.

To compute the radius of a circumscribing circle when the length of one side is given: Multiply the length of a side of the polygon by the number in column B.

To compute the length of a side of a polygon that is contained in a given circle when the radius of the circle is given: Multiply the radius of the circle by the number opposite the name of the desired polygon in column C.

To compute the radius of a circle that can be inscribed in a given polygon when the length of a side is given: Multiply the length of a side of the polygon by the number opposite the name of the polygon in column D.

MULTIPLIERS FOR FACILITATING CALCULATIONS.

Cubic inches × .4103 = lbs. of lead.
Cubic inches × .3225 = lbs. of copper.
Cubic inches × .328 = lbs. of cast copper.
Cubic inches × .268 = lbs. of tin.
Cubic inches × .304 = lbs. of brass.
Cubic inches × .253 = lbs. of zinc.
Cubic inches × .260 = lbs. of cast iron.
Cubic inches × .282 = lbs. of wrought iron.
Cubic inches × .004329 = U. S. gallons.
Cubic inches × .00058 = cubic feet.
Cubic inches × .000466 = U. S. bushel.
Cubic inches of water × .03617 = lbs. avoir.
One cubic inch of water = .0361 lb.
Cubic feet × .03704 = cubic yards.
Cubic feet × .8036 = U. S. bushel.
Cubic feet × 7.48 = U. S. gallons.
Cubic feet of wa'er × 62.42 = lbs. avoir.
One cubic foot of water = 62.42 lbs. avoir.
1.6 cubic feet of water = 1 cwt. (100).
32.04 cubic feet of water = 1 ton (2000).
1.8 cubic feet of water = 1 cwt. (112).
35.88 cubic feet of water = 1 ton (2240).
Square inches × .007 = square feet.
Square feet × .111 = square yards.
Circular inches × .00546 = square feet.
183.346 circular inches = 1 square foot.
Cylindrical inches × .0004546 = cubic feet.
Cylindrical inches × .0034 = U. S. gallons.
Cylindrical inch s of water × .02842 = lbs. avoir.
Cylindrical feet of water × 49.1 = lbs. avoir.
Cylindrical feet × 5.874 = U. S. gallons.
One cylindrical inch of water = .0284 lb.
One cylindrical foot of water = 49.10 lbs.
2200 cylindrical inches = 1 cubic foot.
U. S. bushel × .0495 = cubic yards.
    "   "   × 1.2446 =   "   feet.
    "   "   × 2150.42 =   "   inches.

U. S. gallons × .13367 = cubic feet.

U. S. gallon liquid measure × 231 = cubic inches.

13.44 U. S. gal. of water = 1 cwt. (112).

 68.8 "   "   "   "   = 1 ton (2240).

12   "   "   "   "   = 1 cwt. (100).

240   "   "   "   "   = 1 ton (2000).

One gallon of water   = 8 34 lbs.

One gallon = .13368056 cubic foot.

Lbs. avoirdupois × .009   = cwt. (112).

  "   "   × .00045 = tons (2240).

One pound of water = 27.7 cubic inches.

One pound of water = .16 cubic foot.

Lineal feet   × .00019 = miles.

  "   yards   × .0006   =   "

  '   links   × .22   = yards.

  "   "   × .66   = feet.

  "   feet   × 1.5   = links.

Square yards   × .0002067 = acres.

Acres   × .4840   = square yards.

Width in chains × 8.   = acres per mile.

Velocity in feet per second × .68 = miles per hour.

Velocity in feet per second × .60 = feet per minute.

Velocity in feet per second × .20 = yards per minute.

Inches per second × 5 = feet per minute.

Inches per second × 300 = feet per hour.

Head of water in feet = pressure of water in lbs. per square foot
   × .016.

Head in feet × .434 = lbs. per square inch.

Pounds per square inch × 2.3 = head in feet.

Pressure of water in lbs. per square foot = head in feet × 62.32.

One po·nd p·essure of water = 2.042-inch column of mercury.

Column of water 12 inches high, 1 inch diameter = .341 lb.

One atmosphere = 2116.3 lbs. per square foot.

One atmosphere = 33.947 feet of water at 62 degrees Fahrenheit.

One circular mill is the area of a circle .001 inch in diameter.

1,000,000 circular mills = one circular inch.

AREAS OF CIRCLES AND SIDES OF SQUARES OF SAME AREA.

(Diameter multiplied by .8862 equals sides of an equal square.)

Diameter of Circle in Inches.	Area of Circle in Square Inches.	Sides of Square of Same Area in Square Inches.	Diameter of Circle in Inches.	Area of Circle in Square Inches.	Sides of Square of Same Area in Square Inches.	Diameter of Circle in Inches.	Area of Circle in Square Inches.	Sides of Square of Same Area in Square Inches.
1	.785	.89	21	346.36	18.61	41	1320.26	36.34
1½	1.767	1.33	21½	363.05	19.05	41½	1352.66	36.78
2	3.142	1.77	22	380.13	19.50	42	1385.45	37.22
2½	4.909	2.22	22½	397.61	19.94	42½	1418.63	37.66
3	7.069	2.66	23	415.48	20.38	43	1452.20	38.11
3½	9.621	3.10	23½	433.74	20.83	43½	1486.17	38.55
4	12.566	3.54	24	452.39	21.27	44	1520.53	38.99
4½	15.904	3.99	24½	471.44	21.71	44½	1555.29	39.44
5	19.635	4.43	25	490.88	22.16	45	1590.43	39.88
5½	23.758	4.87	25½	510.71	22.60	45½	1625.97	40.32
6	28.274	5.32	26	530.93	23.04	46	1661.91	40.77
6½	33.183	5.76	26½	551.55	23.49	46½	1698.23	41.21
7	38.485	6.20	27	572.56	23.93	47	1734.95	41.65
7½	44.179	6.65	27½	593.96	24.37	47½	1772.06	42.10
8	50.266	7.09	28	615.75	24.81	48	1809.56	42.58
8½	56.745	7.53	28½	637.94	25.26	48½	1847.46	42.98
9	63.617	7.98	29	660.52	25.70	49	1885.75	43.43
9½	70.882	8.42	29½	683.49	26.14	49½	1924.43	43.87
10	78.540	8.86	30	706.86	26.59	50	1963.50	44.31
10½	86.590	9.30	30½	730.62	27.03	50½	2002.97	44.75
11	95.03	9.75	31	754.77	27.47	51	2042.83	45.20
11½	103.87	10.19	31½	779.31	27.92	51½	2083.08	45.64
12	113.10	10.63	32	804.25	28.36	52	2123.72	46.08
12½	122.72	11.08	32½	829.58	28.80	52½	2164.76	46.53
13	132.73	11.52	33	855.30	29.25	53	2206.19	46.97
13½	143.14	11.96	33½	881.41	29.69	53½	2248.01	47.41
14	153.94	12.41	34	907.92	30.13	54	2290.23	47.86
14½	165.13	12.85	34½	934.82	30.57	54½	2332.83	48.30
15	176.72	13.29	35	962.11	31.02	55	2375.83	48.74
15½	188.69	13.74	35½	989.80	31.46	55½	2419.23	49.19
16	201.06	14.18	36	1017.88	31.90	56	2463.01	49.63
16½	213.83	14.62	36½	1046.35	32.35	56½	2507.19	50.07
17	226.98	15.07	37	1075.21	32.79	57	2551.76	50.51
17½	240.53	15.51	37½	1104.47	33.23	57½	2596.73	50.96
18	254.47	15.95	38	1134.12	33.68	58	2642.09	51.40
18½	268.80	16.40	38½	1164.16	34.12	58½	2687.84	51.84
19	283.53	16.84	39	1194.59	34.56	59	2733.89	52.29
19½	298.65	17.28	39½	1225.42	35.01	59½	2780.51	52.73
20	314.16	17.72	40	1256.64	35.45	60	2827.74	53.17
20½	330.06	18.17	40½	1288.25	35.89			

DECIMALS OF A FOOT FOR EACH $\frac{1}{64}$ OF AN INCH.

Inch.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″
0	0	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167
1/64	.0013	.0846	.1680	.2513	.3346	.4180	.5013	.5846	.6680	.7513	.8346	.9180
1/32	.0026	.0859	.1693	.2526	.3359	.4193	.5026	.5859	.6693	.7526	.8359	.9193
3/64	.0039	.0872	.1706	.2539	.3372	.4206	.5039	.5872	.6706	.7539	.8372	.9206
1/16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219
5/64	.0065	.0898	.1732	.2565	.3398	.4232	.5065	.5898	.6732	.7565	.8398	.9232
3/32	.0078	.0911	.1745	.2578	.3411	.4245	.5078	.5911	.6745	.7578	.8411	.9245
7/64	.0091	.0924	.1758	.2591	.3424	.4258	.5091	.5924	.6758	.7591	.8424	.9258
1/8	.0104	.0937	.1771	.2604	.3437	.4271	.5104	.5937	.6771	.7604	.8437	.9271
9/64	.0117	.0951	.1784	.2617	.3451	.4284	.5117	.5951	.6784	.7617	.8451	.9284
5/32	.0130	.0964	.1797	.2630	.3464	.4297	.5130	.5964	.6797	.7630	.8464	.9297
11/64	.0143	.0977	.1810	.2643	.3477	.4310	.5143	.5977	.6810	.7643	.8477	.9310
3/16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323
13/64	.0169	.1003	.1836	.2669	.3503	.4336	.5169	.6003	.6836	.7669	.8503	.9336
7/32	.0182	.1016	.1849	.2682	.3516	.4349	.5182	.6016	.6849	.7682	.8516	.9349
15/64	.0195	.1029	.1862	.2695	.3529	.4362	.5195	.6029	.6862	.7695	.8529	.9362
1/4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375
17/64	.0221	.1055	.1888	.2721	.3555	.4388	.5221	.6055	.6888	.7721	.8555	.9388
9/32	.0234	.1068	.1901	.2734	.3568	.4401	.5234	.6068	.6901	.7734	.8568	.9401
19/64	.0247	.1081	.1914	.2747	.3581	.4414	.5247	.6081	.6914	.7747	.8581	.9414
5/16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427
21/64	.0273	.1107	.1940	.2773	.3607	.4440	.5273	.6107	.6940	.7773	.8607	.9440
11/32	.0286	.1120	.1953	.2786	.3620	.4453	.5286	.6120	.6953	.7786	.8620	.9453
23/64	.0299	.1133	.1966	.2799	.3633	.4466	.5299	.6133	.6966	.7799	.8633	.9466
3/8	.0312	.1146	.1979	.2812	.3646	.4479	.5312	.6146	.6979	.7812	.8646	.9479
25/64	.0326	.1159	.1992	.2826	.3659	.4492	.5326	.6159	.6992	.7826	.8659	.9492
13/32	.0339	.1172	.2005	.2839	.3672	.4505	.5339	.6172	.7105	.7839	.8672	.9505
27/64	.0352	.1185	.2018	.2852	.3685	.4518	.5352	.6185	.7018	.7852	.8685	.9518
7/16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531
29/64	.0378	.1211	.2044	.2878	.3711	.4544	.5378	.6211	.7044	.7878	.8711	.9544
15/32	.0391	.1224	.2057	.2891	.3724	.4557	.5391	.6224	.7057	.7891	.8724	.9557
31/64	.0404	.1237	.2070	.2904	.3737	.4570	.5404	.6237	.7070	.7904	.8737	.9570
1/2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583
33/64	.0430	.1263	.2096	.2930	.3763	.4596	.5430	.6263	.7096	.7930	.8763	.9596
17/32	.0443	.1276	.2109	.2943	.3776	.4609	.5443	.6276	.7109	.7943	.8776	.9609
35/64	.0456	.1289	.2122	.2956	.3789	.4622	.5456	.6289	.7122	.7956	.8789	.9622
9/16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635
37/64	.0482	.1315	.2148	.2982	.3815	.4648	.5482	.6315	.7148	.7982	.8815	.9648
19/32	.0495	.1328	.2161	.2995	.3828	.4661	.5495	.6328	.7161	.7995	.8828	.9661
39/64	.0508	.1341	.2174	.3008	.3841	.4674	.5508	.6341	.7174	.8008	.8841	.9674
5/8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688
41/64	.0534	.1367	.2201	.3034	.3867	.4701	.5534	.6367	.7201	.8034	.8867	.9701
21/32	.0547	.1380	.2214	.3047	.3880	.4714	.5547	.6380	.7214	.8047	.8880	.9714
43/64	.0560	.1393	.2227	.3060	.3893	.4727	.5560	.6393	.7227	.8060	.8893	.9727
11/16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740
45/64	.0586	.1419	.2253	.3086	.3919	.4753	.5586	.6419	.7253	.8086	.8919	.9753
23/32	.0599	.1432	.2266	.3099	.3932	.4766	.5599	.6432	.7266	.8099	.8932	.9766
47/64	.0612	.1445	.2279	.3112	.3945	.4779	.5612	.6445	.7279	.8112	.8945	.9779
3/4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792

DECIMALS OF A FOOT FOR EACH 1/64 OF AN INCH—(Continued).

Inch.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″
49/64	.0638	.1471	.2305	.3138	.3971	.4805	.5638	.6471	.7305	.8138	.8971	.9805
25/32	.0651	.1484	.2318	.3151	.3984	.4818	.5651	.6484	.7318	.8151	.8984	.9818
51/64	.0664	.1497	.2331	.3164	.3997	.4831	.5664	.6497	.7331	.8164	.8997	.9831
13/16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844
53/64	.0690	.1523	.2357	.3190	.4023	.4857	.5690	.6523	.7357	.8190	.9023	.9857
27/32	.0703	.1536	.2370	.3203	.4036	.4870	.5703	.6536	.7370	.8203	.9036	.9870
55/64	.0716	.1549	.2383	.3216	.4049	.4883	.5716	.6549	.7383	.8216	.9049	.9883
7/8	.0729	.1562	.2396	.3229	.4062	.4896	.5729	.6562	.7396	.8229	.9062	.9896
57/64	.0742	.1576	.2409	.3242	.4076	.4909	.5742	.6576	.7409	.8242	.9076	.9909
29/32	.0755	.1589	.2422	.3255	.4089	.4922	.5755	.6589	.7422	.8255	.9089	.9922
59/64	.0768	.1602	.2435	.3268	.4102	.4935	.5768	.6602	.7435	.8268	.9102	.9935
15/16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948
61/64	.0794	.1628	.2461	.3294	.4128	.4961	.5794	.6628	.7461	.8294	.9128	.9961
31/32	.0807	.1641	.2474	.3307	.4141	.4974	.5807	.6641	.7474	.8307	.9141	.9974
63/64	.0820	.1654	.2487	.3320	.4154	.4987	.5820	.6654	.7487	.8320	.9154	.9987
1												1.0000

DECIMALS OF AN INCH FOR EACH 1/64TH.

1/32ds.	1/64ths.	Decimal.	Fraction.	1/32ds.	1/64ths.	Decimal.	Fraction.
	1	.015625			33	.515625	
1	2	.03125		17	34	.53125	
	3	.046875			35	.546875	
2	4	.0625	1/16	18	36	.5625	9/16
	5	.078125			37	.578125	
3	6	.09375		19	38	.59375	
	7	.109375			39	.609375	
4	8	.125	1/8	20	40	.625	5/8
	9	.140625			41	.640625	
5	10	.15625		21	42	.65625	
	11	.171875			43	.671875	
6	12	.1875	3/16	22	44	.6875	11/16
	13	.203125			45	.703125	
7	14	.21875		23	46	.71875	
	15	.234375			47	.734375	
8	16	.25	1/4	24	48	.75	3/4
	17	.265625			49	.765625	
9	18	.28125		25	50	.78125	
	19	.296875			51	.796875	
10	20	.3125	5/16	26	52	.8125	13/16
	21	.328125			53	.828125	
11	22	.34375		27	54	.84375	
	23	.359375			55	.859375	
12	24	.375	3/8	28	56	.875	7/8
	25	.390625			57	.890625	
13	26	.40625		29	58	.90625	
	27	.421875			59	.921875	
14	28	.4375	7/16	30	60	.9375	15/16
	29	.453125			61	.953125	
15	30	.46875		31	62	.96875	
	31	.484375			63	.984375	
16	32	.5	1/2	32	64	1.	1

FIRST AID TO THE INJURED.

USEFUL SUGGESTIONS IN CASES OF ACCIDENTS TO MECHANICS.

ELECTRIC SHOCK.—The patient should be immediately placed in position for artificial respiration, preferably on a table with a cushion under his shoulders to elevate them slightly. Then bring his arms down until his hands rest on his chest, grasp his wrists and press firmly against the lower walls of the chest for a few seconds, then raise the arms outward and upward until the hands meet beyond the head, drawing firmly upward for a few seconds; repeat this procedure ten or fifteen times a minute.

BLEEDING.—If blood spurts from wound, an artery is divided; bind limb tightly above with India-rubber tubing, strap, handkerchief, or scarf, or bend the limb forcibly at next joint above wound, or press flat hand or stone where blood is flowing. If blood flows freely, but does not spurt, a vein is divided; then apply same measures as in case of wounded artery, but below the wound. If scalp is wounded make a pad of cloth or waste, and bandage very tightly over wound with folded pocket-handkerchief.

BURNS AND SCALDS.—Apply lint, cotton, wool, or waste soaked in oil and lime-water, and bind the same on with handkerchief. If necessary to remove clothes cut them off by running knife or scissors along seams.

BROKEN LEG.—Pull on leg steadily and firmly until it is of same length as sound one. Roll up a coat or empty sack into form of a cushion, carefully place leg upon it, then bind the two together with scarfs or handkerchiefs. Do not lift patient from the ground until stretcher is close at hand. Take great pains, by careful lifting, to prevent broken bone coming through skin.

BROKEN THIGH.—Take hold of ankle and, by steady traction, pull limb to same length as sound one; another person must then tie knees together, and afterward the ankles. Both limbs should then be laid over a sack of straw, or folded coat, so as to bend the knees. Patient should on no account be moved until stretcher or cart is close at hand.

BROKEN ARM.—Pull arm to length of sound one. Apply two splints, one outside and the other inside, binding them firmly on with pocket-handkerchiefs. The best splints are made by folding newspapers to necessary length, binding them above and below seat of fracture; anything hard and light, of suitable size, would act equally well; for instance, wood, pasteboard, twigs, leather, etc.

A FEW ODDS AND ENDS FOR THE NOON-HOUR.

A VERY DECEPTIVE PROBLEM.—Cut a piece of paper 8 inches square, containing 64 square inches, to fill a space 5×13 inches and containing 65 square inches.
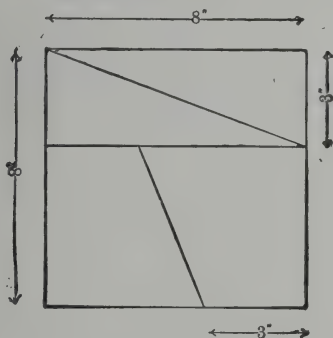
FIG. 216.
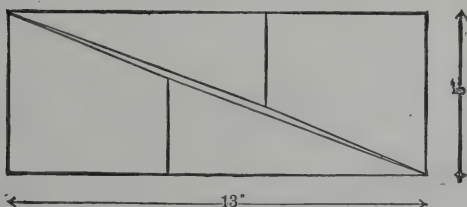
FIG. 217.

Cut the square piece of paper as shown by Fig. 216 and put together as shown by Fig. 217, it will then measure 5×13 inches, but if the sides of the 13-inch figure are kept straight there

will be an opening in the centre as shown. This explains the extra inch.

Which line is the longer, the horizontal or the perpendicular in Fig. 218? Speak quick.

FIG. 218.

TO CUT A BLOCK 12×12 INCHES TO FILL A HOLE 9×16 INCHES. —Cut as shown by Fig. 219 and put together as shown by Fig. 220.
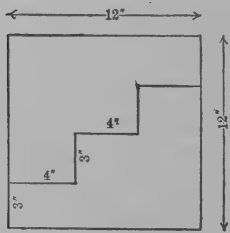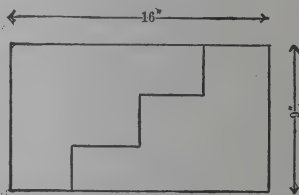
FIG. 219.   FIG. 220.

Which is the greater distance, A to B or B to C, Fig. 221?

FIG. 221.

Draw Fig. 222 without lifting the points of the pencil from the paper, making one continuous line.
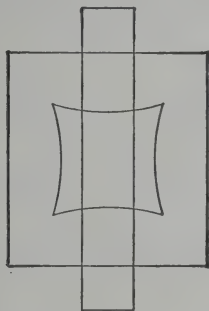
FIG. 222.

To Cut a Five-point Star at One Cut.—Take a square piece of paper and fold it as shown by Fig. 223, 1 to 5, the first
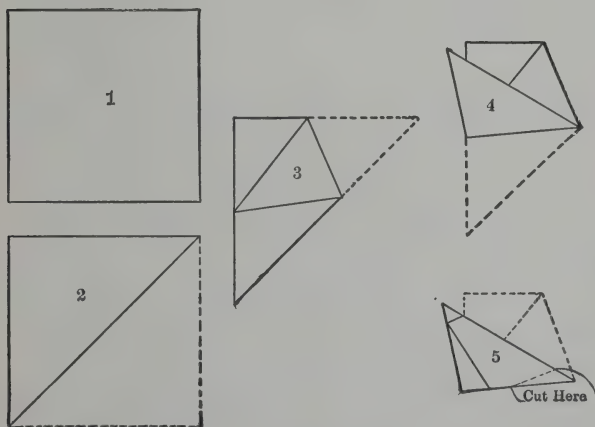
FIG. 223.

fold is shown at 2, the second fold is shown at 3, etc., when folded cut on the line shown in 5,

THE LEAKING-SHIP PROBLEM.—A ship at sea strikes a rock and knocks a hole in the bottom 8×15 inches. The ship's carpenter has a piece of board 10×12 inches. How can he cut it to fill the hole?

Cut it as shown by Fig. 224, and put together as shown by Fig. 225.
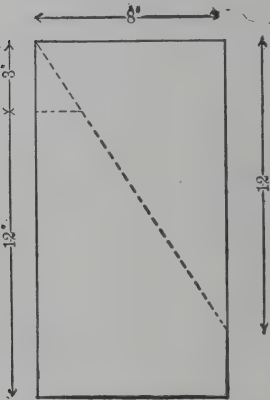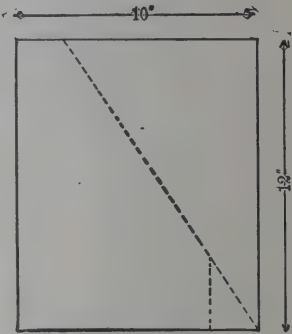
FIG. 224.   FIG. 225.

Which of the horizontal lines in Fig. 226 is the longer?
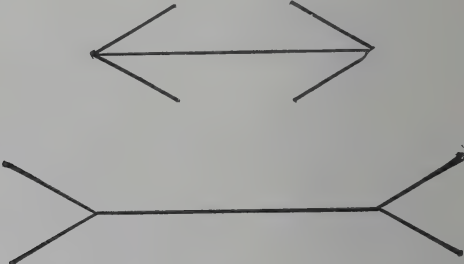
FIG. 226.

Which of the lower diagonal lines in Fig. 227 is in line with the line above.
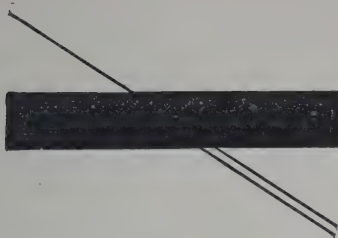
FIG. 227.

Are the horizontal lines in Fig. 228 parallel or not?
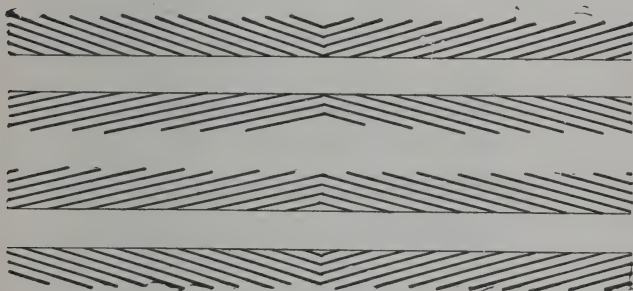
FIG. 228.

Which of the dotted lines in the cross is the longer?
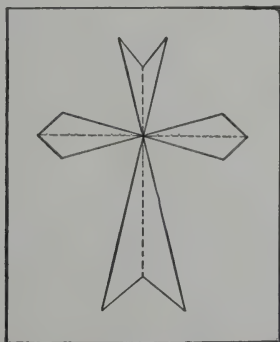
FIG. 229.

Which of the circular sections is the longer, *A* or *B*?

Are the heavy lines in Fig. 231 parallel?

Fig. 232 shows a perfectly straight rule laid over a number of concentric circular rings. As will be seen it gives the rule a
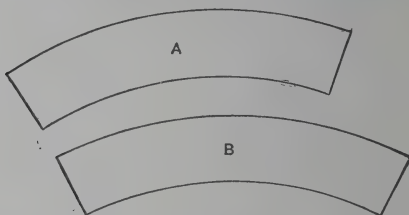
Fig. 230.

Fig. 231.
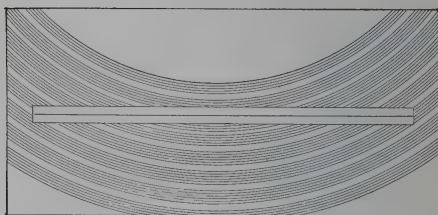
Fig. 232.

curved appearance. The circular rings also appear distorted, as the rings on one side of the rule do not appear to be a continuation of those on the other side, but this can be proved by sighting along the lines.

TOTIN' THE HOD.

When I near some houses building
  With all sorts of stuff around—
Lime and sand and bricks and lumber,
  Dumped upon the uneven ground;
When I see the bed of mortar,
  With a pile all tempered right,
When I see the man that's tending,
  As he works with all his might—
Fills the hod to overflowing,
  Stoops and shoulders it, and then
Mounts the steps or climbs the ladder
  To supply the workingmen;
I don't think of town improvements,
  Nor of scanty, well-earned pelf,
But there comes a kindly feeling—
  For I've "toted" some myself.

Once again I hear the clinking
  Of the trowel on the wall.
Once again I see the sunshine
  On the blinding whiteness fall
Of the lime within the slush-box—
  Watch it crack and hear it boil;
From its rattling detonations
  I can feel myself recoil.
But all these—I pass them over,
  As I watch him with his hoe,
See him load his empty hod up,
  Then into the building go.
But it's not of town improvements,
  Nor of scanty, well-earned pelf,
It's of former days I'm thinking,
  When I "toted" some myself.

And I think, as I am looking,
  If I'd never helped to do
Work that strained and stretched each muscle—
  Gave me soreness through and through—
I had never felt this feeling,
  Kindly, thoughtful, for the man
Who with hod and hoe and shovel,
  Travels in improvement's van.
So you must not count me foolish,
  And perhaps a trifle odd,
If I stop and hold some converse
  With the man beneath the hod.
For you'd have a kindly feeling,
  Far removed from paltry pelf,
Far removed from town improvements,
  If you'd "toted" some yourself.
           JOHN L. SHROY, in *Carpentry and Building*

WAGE-TABLE.

Explanation.—Find the number of days or hours employed, in the left-hand columns, and follow this line out to the column under the rate per day or hour, where will be found the sum due.

Values below are in $ ct. Column headers show **Rate per hour, cents** (top) and **Rate per day, dollars** (bottom).

Days of 8 Hours.	Hours.	75 / 6.00	71.87 / 5.75	68.75 / 5.50	65.62 / 5.25	62.5 / 5.00	59.37 / 4.75	56.25 / 4.50	53.12 / 4.25	50 / 4.00	46.87 / 3.75	43.75 / 3.50	40.62 / 3.25	40 / 3.20	37.5 / 3.00	34.38 / 2.75	31.25 / 2.50	28 / 2.25	25 / 2.00
	½	.38	.36	.34	.33	.31	.30	.28	.26	.25	.23	.22	.20	.20	.19	.17	.16	.14	.13
	1	.75	.72	.69	.66	.63	.59	.56	.53	.50	.47	.44	.41	.40	.38	.34	.31	.28	.25
	1½	1.13	1.08	1.03	.99	.94	.89	.84	.80	.75	.70	.66	.61	.60	.56	.52	.47	.42	.38
¼	2	1.50	1.44	1.38	1.31	1.25	1.19	1.13	1.06	1.00	.94	.88	.81	.80	.75	.69	.63	.56	.50
	2½	1.88	1.80	1.72	1.64	1.56	1.49	1.41	1.33	1.25	1.17	1.09	1.02	1.00	.94	.86	.78	.70	.63
	3	2.25	2.16	2.06	1.97	1.88	1.78	1.69	1.59	1.50	1.41	1.31	1.22	1.20	1.13	1.03	.94	.84	.75
	3½	2.63	2.52	2.41	2.30	2.19	2.08	1.97	1.85	1.75	1.64	1.53	1.42	1.40	1.31	1.20	1.09	.98	.88
½	4	3.00	2.87	2.75	2.62	2.50	2.39	2.25	2.12	2.00	1.88	1.75	1.63	1.60	1.50	1.38	1.25	1.13	1.00
	4½	3.38	3.23	3.09	2.95	2.81	2.67	2.53	2.39	2.25	2.11	1.97	1.83	1.80	1.69	1.55	1.41	1.26	1.13
	5	3.75	3.59	3.44	3.28	3.13	2.97	2.81	2.66	2.50	2.34	2.19	2.03	2.00	1.88	1.72	1.56	1.41	1.25
	5½	4.13	3.95	3.78	3.61	3.44	3.26	3.09	2.92	2.75	2.58	2.41	2.23	2.20	2.06	1.89	1.72	1.55	1.38
¾	6	4.50	4.31	4.13	3.94	3.75	3.56	3.38	3.19	3.00	2.81	2.63	2.44	2.40	2.25	2.06	1.88	1.69	1.50
	6½	4.88	4.67	4.47	4.27	4.07	3.86	3.66	3.45	3.25	3.05	2.84	2.64	2.60	2.44	2.23	2.03	1.83	1.63
	7	5.25	5.03	4.81	4.59	4.38	4.16	3.93	3.72	3.50	3.28	3.06	2.84	2.80	2.63	2.41	2.19	1.97	1.75
	7½	5.63	5.39	5.16	4.92	4.69	4.45	4.22	3.98	3.75	3.52	3.28	3.05	3.00	2.81	2.58	2.34	2.11	1.88
1 day	8	6.00	5.75	5.50	5.25	5.00	4.75	4.50	4.25	4.00	3.75	3.50	3.25	3.20	3.00	2.75	2.50	2.25	2.00
	8½	6.38	6.11	5.84	5.58	5.31	5.05	4.78	4.51	4.25	3.98	3.72	3.45	3.40	3.19	2.92	2.66	2.39	2.13
	9	6.75	6.47	6.19	5.91	5.63	5.34	5.06	4.78	4.50	4.22	3.94	3.66	3.60	3.38	3.09	2.81	2.53	2.25
	9½	7.13	6.83	6.53	6.24	5.94	5.64	5.34	5.05	4.75	4.45	4.16	3.86	3.80	3.56	3.27	2.97	2.67	2.38
1¼	10	7.50	7.19	6.88	6.56	6.25	5.94	5.63	5.31	5.00	4.69	4.38	4.06	4.00	3.75	3.44	3.13	2.81	2.50
	10½	7.88	7.55	7.22	6.89	6.56	6.24	5.91	5.58	5.25	4.92	4.59	4.27	4.20	3.94	3.61	3.28	2.95	2.63
	11	8.25	7.91	7.56	7.22	6.88	6.53	6.19	5.84	5.50	5.16	4.81	4.47	4.40	4.13	3.78	3.44	3.09	2.75
	11½	8.63	8.27	7.91	7.55	7.19	6.83	6.47	6.11	5.75	5.39	5.03	4.67	4.60	4.31	3.95	3.59	3.23	2.88
1½	12	9.00	8.62	8.25	7.87	7.50	7.13	6.75	6.38	6.00	5.63	5.25	4.88	4.80	4.50	4.13	3.75	3.38	3.00

WAGE-TABLE—(Continued).

Explanation.—Find the number of days or hours employed, in the left-hand columns, and follow this line out to the column under the rate per day or hour, where will be found the sum due.

Rate per hour, cents	75	71.87	68.75	65.62	62.5	59.37	56.25	53.12	50	46.87	43.75	40.62	40	37.5	34.38	31.25	28	25
Rate per day, dollars	6.00	5.75	5.50	5.25	5.00	4.75	4.50	4.25	4.00	3.75	3.50	3.25	3.20	3.00	2.75	2.50	2.25	2.00
Days of 8 Hours / Hours	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct
12½	9.38	8.98	8.59	8.20	7.81	7.42	7.03	6.64	6.25	5.86	5.47	5.08	5.00	4.69	4.30	3.91	3.51	3.13
13	9.75	9.34	8.94	8.53	8.13	7.72	7.31	6.91	6.50	6.00	5.69	5.28	5.20	4.88	4.47	4.06	3.66	3.25
13½	10.13	9.70	9.28	8.86	8.44	8.01	7.59	7.17	6.75	6.33	5.91	5.48	5.40	5.06	4.64	4.22	3.80	3.38
14 (1¾)	10.50	10.06	9.63	9.19	8.75	8.31	7.88	7.44	7.00	6.56	6.13	5.69	5.60	5.25	4.81	4.38	3.94	3.50
14½	10.88	10.42	9.97	9.52	9.07	8.61	8.16	7.71	7.25	6.80	6.34	5.89	5.80	5.44	4.98	4.53	4.08	3.63
15	11.25	10.78	10.31	9.84	9.38	8.91	8.44	7.97	7.50	7.03	6.56	6.09	6.00	5.63	5.16	4.69	4.22	3.75
15½	11.63	11.14	10.66	10.17	9.69	9.20	8.72	8.23	7.75	7.27	6.78	6.30	6.20	5.81	5.33	4.84	4.36	3.88
16 (2 days)	12.00	11.50	11.00	10.50	10.00	9.50	9.00	8.50	8.00	7.50	7.00	6.50	6.40	6.00	5.50	5.00	4.50	4.00
16½	12.38	11.86	11.34	10.83	10.31	9.80	9.28	8.76	8.25	7.73	7.22	6.70	6.60	6.19	5.67	5.16	4.64	4.13
17	12.75	12.22	11.69	11.16	10.63	10.09	9.56	9.03	8.50	7.97	7.44	6.91	6.80	6.38	5.84	5.31	4.78	4.25
17½	13.13	12.58	12.03	11.49	10.94	10.39	9.84	9.30	8.75	8.20	7.66	7.11	7.00	6.56	6.02	5.47	4.92	4.38
18 (2¼)	13.50	12.94	12.37	11.81	11.25	10.69	10.13	9.56	9.00	8.44	7.88	7.31	7.20	6.75	6.19	5.63	5.06	4.50
18½	13.88	13.30	12.72	12.14	11.56	10.99	10.41	9.83	9.25	8.67	8.09	7.52	7.40	6.94	6.36	5.78	5.20	4.63
19	14.25	13.66	13.06	12.47	11.88	11.28	10.69	10.09	9.50	8.91	8.31	7.72	7.60	7.13	6.53	5.94	5.34	4.75
19½	14.63	14.04	13.41	12.80	12.19	11.58	10.97	10.36	9.75	9.14	8.53	7.92	7.80	7.31	6.70	6.09	5.48	4.88
20 (2½)	15.00	14.37	13.75	13.12	12.50	11.88	11.25	10.63	10.00	9.38	8.75	8.13	8.00	7.50	6.88	6.25	5.63	5.00
20½	15.38	14.73	14.09	13.45	12.81	12.17	11.53	10.89	10.25	9.61	8.97	8.33	8.20	7.69	7.05	6.41	5.76	5.13
21	15.75	15.09	14.44	13.78	13.13	12.47	11.81	11.16	10.50	9.84	9.19	8.53	8.40	7.88	7.22	6.56	5.91	5.25
21½	16.13	15.45	14.78	14.11	13.44	12.76	12.09	11.42	10.75	10.08	9.41	8.73	8.60	8.06	7.39	6.72	6.04	5.38
22 (2¾)	16.50	15.81	15.13	14.44	13.75	13.06	12.38	11.69	11.00	10.31	9.63	8.94	8.80	8.25	7.56	6.88	6.19	5.50
22½	16.88	16.17	15.47	14.77	14.07	13.36	12.66	11.96	11.25	10.55	9.84	9.14	9.00	8.44	7.73	7.03	6.33	5.63
23	17.25	16.53	15.81	15.09	14.38	13.66	12.93	12.22	11.50	10.78	10.06	9.34	9.20	8.63	7.91	7.19	6.47	5.75
23½	17.63	16.89	16.16	15.42	14.69	13.95	13.22	12.48	11.75	11.02	10.28	9.55	9.40	8.81	8.08	7.34	6.61	5.88
24 (3 days)	18.00	17.25	16.50	15.75	15.00	14.25	13.50	12.75	12.00	11.25	10.50	9.75	9.60	9.00	8.25	7.50	6.75	6.00

WAGE-TABLE.—(Continued).

Explanation.—Find the number of days or hours employed, in the left-hand columns, and follow this line out to the column under the rate per day or hour, where will be found the sum due.

Rate per hour, cents		75	71.87	68.75	65.62	62.5	59.37	56.25	53.12	50	46.87	43.75	40.62	40	37.5	34.38	31.25	28	25
Rate per day, dollars		6.00	5.75	5.50	5.25	5.00	4.75	4.50	4.25	4.00	3.75	3.50	3.25	3.20	3.00	2.75	2.50	2.25	2.00
Days of 8 Hours	Hours	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct
	24½	18.38	17.61	16.84	16.08	15.31	14.55	13.78	13.02	12.25	11.48	10.72	9.95	9.80	9.19	8.42	7.66	6.89	6.13
	25	18.75	17.97	17.19	16.41	15.63	14.84	14.06	13.28	12.50	11.72	10.94	10.16	10.00	9.38	8.59	7.81	7.03	6.25
	25½	19.13	18.33	17.53	16.73	15.94	15.14	14.34	13.55	12.75	11.95	11.16	10.36	10.20	9.56	8.77	7.97	7.17	6.38
3¼	26	19.50	18.69	17.88	17.06	16.25	15.44	14.63	13.81	13.00	12.19	11.38	10.56	10.40	9.75	8.94	8.13	7.31	6.50
	26½	19.88	19.05	18.22	17.39	16.56	15.73	14.91	14.08	13.25	12.42	11.59	10.77	10.60	9.94	9.11	8.28	7.45	6.63
	27	20.25	19.41	18.56	17.72	16.88	16.03	15.19	14.34	13.50	12.66	11.81	10.97	10.80	10.13	9.28	8.44	7.59	6.75
	27½	20.63	19.77	18.91	18.05	17.19	16.33	15.47	14.61	13.75	12.89	12.03	11.17	11.00	10.31	9.45	8.59	7.73	6.88
3½	28	21.00	20.13	19.25	18.38	17.50	16.63	15.75	14.88	14.00	13.13	12.25	11.38	11.20	10.50	9.63	8.75	7.88	7.00
	28½	21.38	20.48	19.59	18.70	17.81	16.92	16.03	15.14	14.25	13.36	12.47	11.58	11.40	10.69	9.80	8.91	8.02	7.13
	29	21.75	20.84	19.94	19.03	18.13	17.22	16.31	15.41	14.50	13.59	12.69	11.78	11.60	10.88	9.97	9.06	8.16	7.25
	29½	22.13	21.20	20.28	19.36	18.44	17.52	16.59	15.67	14.75	13.83	12.91	11.98	11.80	11.06	10.14	9.22	8.30	7.38
3¾	30	22.50	21.56	20.63	19.69	18.75	17.81	16.88	15.94	15.00	14.06	13.13	12.19	12.00	11.25	10.31	9.38	8.44	7.50
	30½	22.88	21.92	20.97	20.02	19.06	18.11	17.16	16.20	15.25	14.30	13.34	12.39	12.20	11.44	10.48	9.53	8.58	7.63
	31	23.25	22.28	21.31	20.34	19.38	18.41	17.44	16.47	15.50	14.53	13.56	12.59	12.40	11.63	10.66	9.69	8.72	7.75
	31½	23.63	22.64	21.66	20.67	19.69	18.70	17.72	16.73	15.75	14.77	13.78	12.80	12.60	11.81	10.83	9.84	8.86	7.88
4 days	32	24.00	23.00	22.00	21.00	20.00	19.00	18.00	17.00	16.00	15.00	14.00	13.00	12.80	12.00	11.00	10.00	9.00	8.00
	32½	24.38	23.36	22.34	21.33	20.31	19.30	18.28	17.27	16.25	15.23	14.22	13.20	13.00	12.19	11.17	10.16	9.14	8.13
	33	24.75	23.72	22.69	21.66	20.63	19.59	18.56	17.53	16.50	15.47	14.44	13.41	13.20	12.38	11.34	10.31	9.28	8.25
	33½	25.13	24.08	23.03	21.98	20.94	19.89	18.84	17.80	16.75	15.70	14.66	13.61	13.40	12.56	11.52	10.47	9.42	8.38
4¼	34	25.50	24.44	23.38	22.31	21.25	20.19	19.13	18.06	17.00	15.94	14.88	13.81	13.60	12.75	11.69	10.63	9.56	8.50
	34½	25.88	24.80	23.72	22.64	21.56	20.48	19.41	18.33	17.25	16.17	15.09	14.02	13.80	12.94	11.86	10.78	9.70	8.63
	35	26.25	25.16	24.06	22.97	21.88	20.78	19.69	18.59	17.50	16.41	15.31	14.22	14.00	13.13	12.03	10.94	9.84	8.75
	35½	26.63	25.52	24.41	23.30	22.19	21.08	19.97	18.86	17.75	16.64	15.53	14.42	14.20	13.31	12.20	11.09	9.98	8.88
4½	36	27.00	25.88	24.75	23.63	22.50	21.38	20.25	19.13	18.00	16.88	15.75	14.63	14.40	13.50	12.38	11.25	10.13	9.00

WAGE-TABLE.—(Continued).

Explanation.—Find the number of days or hours employed, in the left-hand columns, and follow this line out to the column under the rate per day or hour, where will be found the sum due.

Days of 8 Hours	Hours	75	71.87	68.75	65.62	62.5	59.37	56.25	53.12	50	46.87	43.75	40.62	40	37.5	34.38	31.25	28	25
Rate per day, dollars.		6.00	5.75	5.50	5.25	5.00	4.75	4.50	4.25	4.00	3.75	3.50	3.25	3.20	3.00	2.75	2.50	2.25	2.00
		$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct
4½	36½	27.38	26.23	25.09	23.95	22.81	21.68	20.53	19.38	18.25	17.11	15.97	14.83	14.60	13.69	12.55	11.41	10.26	9.13
	37	27.75	26.59	25.44	24.27	23.13	21.97	20.81	19.65	18.50	17.34	16.19	15.03	14.80	13.88	12.72	11.56	10.41	9.25
	37½	28.13	26.95	25.78	24.60	23.44	22.27	21.09	19.92	18.75	17.58	16.41	15.23	15.00	14.06	12.89	11.72	10.55	9.38
4¾	38	28.50	27.31	26.13	24.93	23.75	22.57	21.38	20.19	19.00	17.81	16.63	15.44	15.20	14.25	13.06	11.88	10.69	9.50
	38½	28.88	27.67	26.47	25.26	24.06	22.87	21.66	20.45	19.25	18.05	16.84	15.64	15.40	14.44	13.23	12.03	10.83	9.63
	39	29.25	28.03	26.82	25.58	24.38	23.16	21.93	20.71	19.50	18.28	17.06	15.84	15.60	14.63	13.41	12.19	10.97	9.75
	39½	29.63	28.39	27.16	25.91	24.69	23.46	22.22	20.97	19.75	18.52	17.28	16.05	15.80	14.81	13.58	12.34	11.11	9.88
5 days	40	30.00	28.75	27.50	26.25	25.00	23.75	22.50	21.24	20.00	18.75	17.50	16.25	16.00	15.00	13.75	12.50	11.25	10.00
	40½	30.38	29.11	27.84	26.58	25.31	24.05	22.78	21.51	20.25	18.98	17.72	16.45	16.20	15.19	13.92	12.66	11.39	10.13
	41	30.75	29.47	28.19	26.91	25.63	24.34	23.06	21.78	20.50	19.22	17.94	16.66	16.40	15.38	14.09	12.81	11.53	10.25
	41½	31.13	29.83	28.53	27.24	25.94	24.64	23.34	22.04	20.75	19.45	18.16	16.86	16.60	15.56	14.27	12.97	11.67	10.38
5¼	42	31.50	30.19	28.88	27.56	26.25	24.94	23.63	22.30	21.00	19.69	18.38	17.06	16.80	15.75	14.44	13.13	11.81	10.50
	42½	31.88	30.55	29.22	27.89	26.56	25.23	23.91	22.57	21.25	19.92	18.59	17.27	17.00	15.94	14.61	13.28	11.95	10.63
	43	32.25	30.91	29.56	28.22	26.88	25.53	24.19	22.83	21.50	20.16	18.81	17.47	17.20	16.13	14.78	13.44	12.09	10.75
	43½	32.63	31.27	29.91	28.55	27.19	25.83	24.47	23.10	21.75	20.39	19.03	17.67	17.40	16.31	14.95	13.59	12.23	10.88
5½	44	33.00	31.62	30.25	28.88	27.50	26.13	24.75	23.36	22.00	20.63	19.25	17.88	17.60	16.50	15.13	13.75	12.38	11.00
	44½	33.38	31.98	30.59	29.20	27.81	26.42	25.03	23.63	22.25	20.86	19.47	18.08	17.80	16.69	15.30	13.91	12.51	11.13
	45	33.75	32.34	30.94	29.53	28.13	26.73	25.31	23.90	22.50	21.09	19.69	18.28	18.00	16.88	15.47	14.06	12.66	11.25
	45½	34.13	32.70	31.28	29.86	28.44	27.01	25.59	24.17	22.75	21.33	19.91	18.48	18.20	17.06	15.64	14.22	12.80	11.38
5¾	46	34.50	33.06	31.63	30.19	28.75	27.31	25.88	24.43	23.00	21.56	20.13	18.69	18.40	17.25	15.81	14.38	12.94	11.50
	46½	34.88	33.42	31.97	30.52	29.06	27.61	26.16	24.70	23.25	21.80	20.34	18.89	18.60	17.44	15.98	14.53	13.08	11.63
	47	35.25	33.78	32.31	30.84	29.38	27.92	26.44	24.96	23.50	22.03	20.56	19.09	18.80	17.63	16.16	14.69	13.22	11.75
	47½	35.63	34.14	32.66	31.17	29.69	28.21	26.72	25.23	23.75	22.27	20.78	19.30	19.00	17.81	16.33	14.84	13.36	11.88
6 days	48	36.00	34.50	33.00	31.50	30.00	28.50	27.00	25.50	24.00	22.50	21.00	19.50	19.20	18.00	16.50	15.00	13.50	12.00

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